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Another Example of Poor Wiring

Where It Would Not Be Expected and Will Sometime Prove Very Expensive

UNDER date of October 22 I received the following letter and photo from E. S. Lincoln, a consulting electrical engineer at Portland, Maine. It was evidently called forth by the comment on page 461 of the October issue dealing with the wiring about transformers at the point where electrical service is brought into an industrial plant.

I have noticed from time to time in INDUSTRIAL ENGINEER a number of photographs exposing some undesirable wiring in the industrial plant.

I am enclosing herewith a photograph taken in a central station which shows some pretty poor wiring for 2,300-volt service. I can readily see how some industrial plants would slip up, since electric service is only one of their many troubles, but the central station has little excuse, as it is their main line of business. It is certainly surprising to see what some of these operating companies will do in the way of construction.

In the last few years, however, there has been a decided change for the better and practically all of the large companies and a number of the smaller ones are bettering conditions every day. On the other hand, it would do some central station men good to visit some of their industrial customers and get a few pointers on first-class wiring.

I am particularly glad that Mr. Lincoln has selected this horrible example of poor wiring from a central station installation for it goes to show that industrial men are not the only ones guilty of patching up a job that was already a mess before the patching operation began. I agree with Mr. Lincoln that in some cases there may be some justification for the existence of these eyesores of wiring in industrial plants where the man responsible for installation work has a hundred and one things to do, with only one head and one pair of hands and not enough hours in the day to get to all the things he would like to do. But when this is the case the opportunity presents itself to show the boss the need for more help and the actual loss through accidents and lost time in production by allowing patched-up and temporary work to become permanent, by reason of the fact that nothing has happened. When the thing does happen that is expected, and time and natural wear and tear will certainly collect their due, the old saying about spilt milk will not only be true but prove that procrastination is the most reliable thief of good intentions that the world has ever known. And, too, no one ever gets much sympathy for excuses; it's the fellow with less ability, perhaps, but with the "do-it-now" spirit who is considered the smart fellow and gets the raises.

But don't overlook the last sentence of Mr. Lincoln's letter. There he gives to the devil and his hindermost followers the credit that is due them. Some of the best wiring I have ever seen, best because it shows care in layout and workmanship, has been in industrial plants and I had something to say about these in the articles on "Where Wiring Can Be Improved Around Machines," in the May and June issues.

We would like to show up more of the good wiring jobs that you men are proud of; so if you have an installation that you believe is up to date in particular respects, let us say something about it in INDUSTRIAL ENGINEER.

Practical Pete

A Glimpse Into the Works of the

Elgin National Watch Company

Where by careful and accurate machine and hand-work gold, silver, platinum, steel, and brass are turned into high-grade watches, and every part, even to the smallest screw, is made interchangeable

PROBABLY few industries call for more perfect lighting than watch-making; also few require such a combination of careful and accurate machine- and hand-work on small pieces. Standard-size watch movements contain about 211 separate pieces, about a third of which are screws, assembled together between plates. The movements vary in size from the smallest ladies' wrist watches about 0.7 inch in diameter to the 18-size man's watch, which is about 1.766 inches in diameter.

Watches today are vastly different from the early watches made about four hundred years ago, which were about the size of a large alarm clock. The first watch was made entirely of iron, in 1504, and was about 6 in. in height. It had only one hand and lost about an hour a day. Many of the principles of the first watches and clocks, with refinements and improvements, however, are still incorporated in modern time-pieces. These are, for example, the time train, the balance wheel and for clocks, the pendulum. Much of the improvement has been in the escapement, which controls the action of the clock or watch to make it keep accurate time.

The first watch, made in 1504.
Peter Henlein, a young locksmith of Nuremburg, Germany, is credited with making the first so-called watch. This was spring-driven, about 6 in. in diameter, was made entirely of iron and lost about an hour a day.

The accuracy with which a watch must operate if it is to keep time is shown by the fact that the balance wheel must vibrate exactly five times a second or 18,000 times an hour. One more or less vibration an hour will make the watch run 4.8 seconds fast or slow a day, or 2.4 minutes a month. Much greater accuracy is expected from even moderate-priced watches and is required in watches used to control the operation of trains.

The Elgin, Ill., factory of the Elgin National Watch Co., and its observatory.
Two astronomers are in charge of the Elgin observatory where time is taken from the stars. This is used to check the timing of special, precision clocks enclosed in hermetically-sealed glass jars. These clocks are the standard for timing Elgin watches. The Elgin factory consists of a group of buildings in the form of a large quadrangle. They are narrow with windows on both sides extending to the high ceilings, to give as much natural light as possible. Much of the handwork in a watch is performed under the magnifying glass; so lighting is an important consideration.

Two steps in watchmaking—ornamenting the plates and (right) drawing hairsprings.

The machine above ornaments ten watch plates at a time, with geometric scroll work. It operates on the pantagraph principle and reproduces the movements of an electric stylus over a pattern or master plate. The various holes on the watch plate are represented by insulated inserts on the master plate. When the electric stylus touches these inserts the cutting tools are automatically lifted from all ten watch plates to avoid damaging these points. The earliest watches did not have a hairspring. Later pig bristles were used. In modern watches the accuracy is controlled by the hairspring and balance wheel. These springs are drawn through a diamond die (right) which will draw 100 miles of hairspring wire before wearing out. The best steel dies will draw only 8 miles.

Watch and clock making requires a comparatively small amount of power as it is light manufacturing and much of it is hand-work. It does, however, require a degree of care and skill much greater than is ordinarily required in most industries.

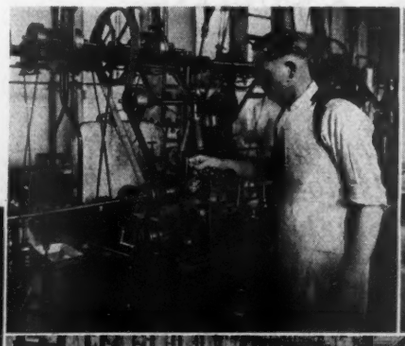
One of the pioneers and leaders of the development of the watch and clock industry in the United States is the Elgin National Watch Company, Elgin, Ill. This was started in 1864 under the name of the National Watch Company by B. W. Raymond, a pioneer in mid-western industrial enterprises. The company is now under the administration of its fourth president since its organization. Today it is producing about 1,000,000 watches annually. The present plant, shown in an accompanying illustration, employs about 3,500 to 4,000 men and women.

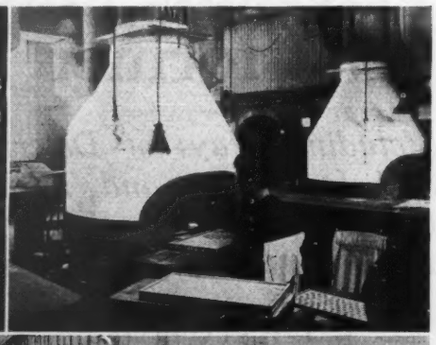
Watch-making was originally a hand process. The first successful attempt to make it a machine process was in 1840. Since then many improvements have been made in the manufacture of watches and now all parts are made by machinery. This permits of standardized manufacture and interchangeability of parts in practically all American watches. A repair part that will fit can be purchased almost anywhere in the world and inserted by a competent watch repairer.

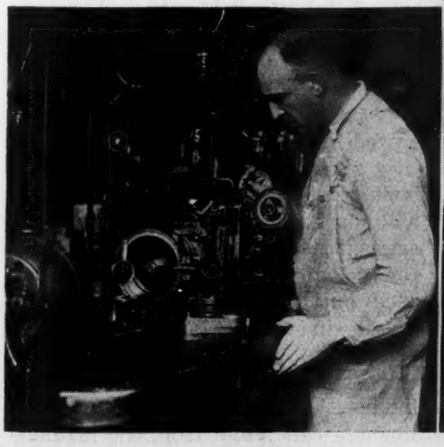
There are 3,773 separate operations in making a 23-jewel Elgin watch. *(Continued on page 604)*

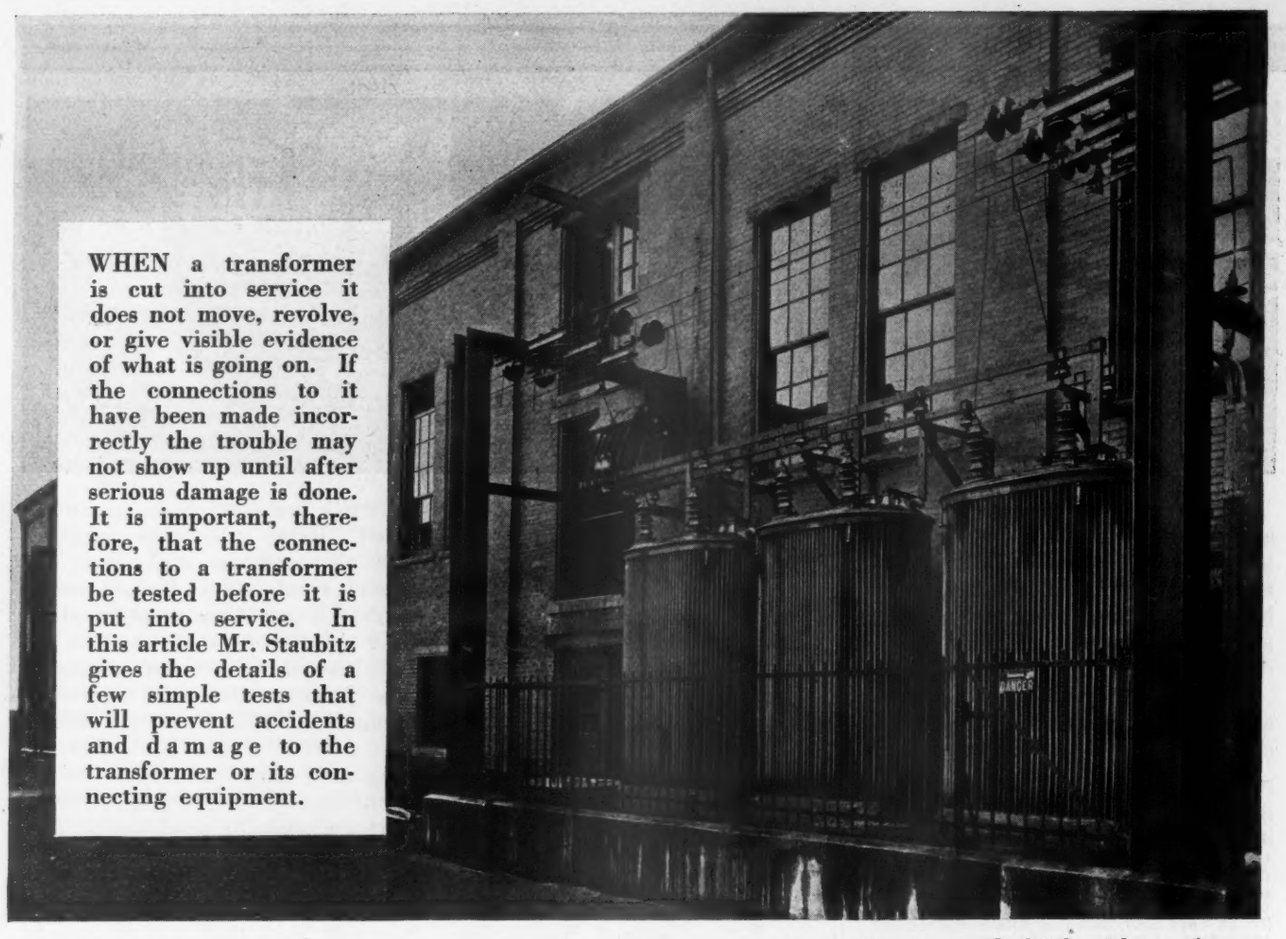
Some of the special machines required in watchmaking.

When watchmaking became a manufacturing process instead of handwork it became possible to standardize the parts and make them interchangeable. To do this economically has required the invention of many special machines. One of these, the automatic pinion turning machine, is shown below. Another, the automatic jewel setting machine (center) not only makes the setting but sets sixteen jewels a minute. Jewels, made from ruby or garnet, form the more important watch bearings. Standard watches are made with seven to twenty-three jewels. One drop of oil a year properly applied, lubricates a watch. Dial making (right) is another interesting process. The operator feeds the dials into the front of the furnace and they drop out the back when finished. The numerals are then printed on and baked in. After the different parts of a watch are assembled, with the exception of balance, dial and hands, they go to the finishing room (lower right). Here expert craftsmen inspect the work and finish the assembly. The movement is then tested and adjusted and is ready for use when inserted in a case.









WHEN a transformer is cut into service it does not move, revolve, or give visible evidence of what is going on. If the connections to it have been made incorrectly the trouble may not show up until after serious damage is done. It is important, therefore, that the connections to a transformer be tested before it is put into service. In this article Mr. Staubitz gives the details of a few simple tests that will prevent accidents and damage to the transformer or its connecting equipment.

Here is a standard industrial type of transformer installation used by one large company. This bank of transformers is delta connected on both the high- and low-tension sides. In this article are given several precautions that must be observed before such a bank is thrown into service for the first time.

Practical Tests That You Can Use In

Checking and Testing Transformer Connections

Including Ways of Determining Ratio, Polarity and Impedance and Things to Be Done Before Connecting or Paralleling Single-Phase or Three-Phase Banks of Transformers

By L. P. STAUBITZ
Chief Electrician, Laclede Steel Company, Alton, Illinois

MANY interesting and practical problems are met in the operation of both single-phase and polyphase transformers. A transformer is usually thought of as being such a simple piece of apparatus that in many cases it is often considered unnecessary to make any tests before placing it in operation. However, a few carefully-made tests taken at the time of installation are good insurance against accidents or damage to the transformer and will greatly assist in making connections and solving any trouble that may arise.

If a transformer is to be operated entirely alone on both the primary and secondary sides, practically the only tests needed would be the regular insulation test, test of transformer oil, and possibly a voltage-regulation test. If the transformer were installed on a public utility system the public service company would, no doubt, complete the other usual tests including magnetizing loss, which represents the amount of energy required to keep the transformer alive without any secondary load.

Where transformers are to be operated in parallel with others, a knowledge of the characteristics of the transformer, gained from tests, is of great value.

If two transformers are to be operated in parallel it is necessary that they should both have the same polarity; otherwise one transformer will short circuit the other with disastrous results. One way of testing for polarity—this method is often used but is not to be recommended—is to connect the new transformer to the bus on the low-voltage side and cut in the high-tension winding through a fuse. The lineman can judge from the manner in which the fuse is blown whether or not the transformer is of the cor-

rect polarity. Usually the polarity is known from the make of the transformer, thus aiding the test.

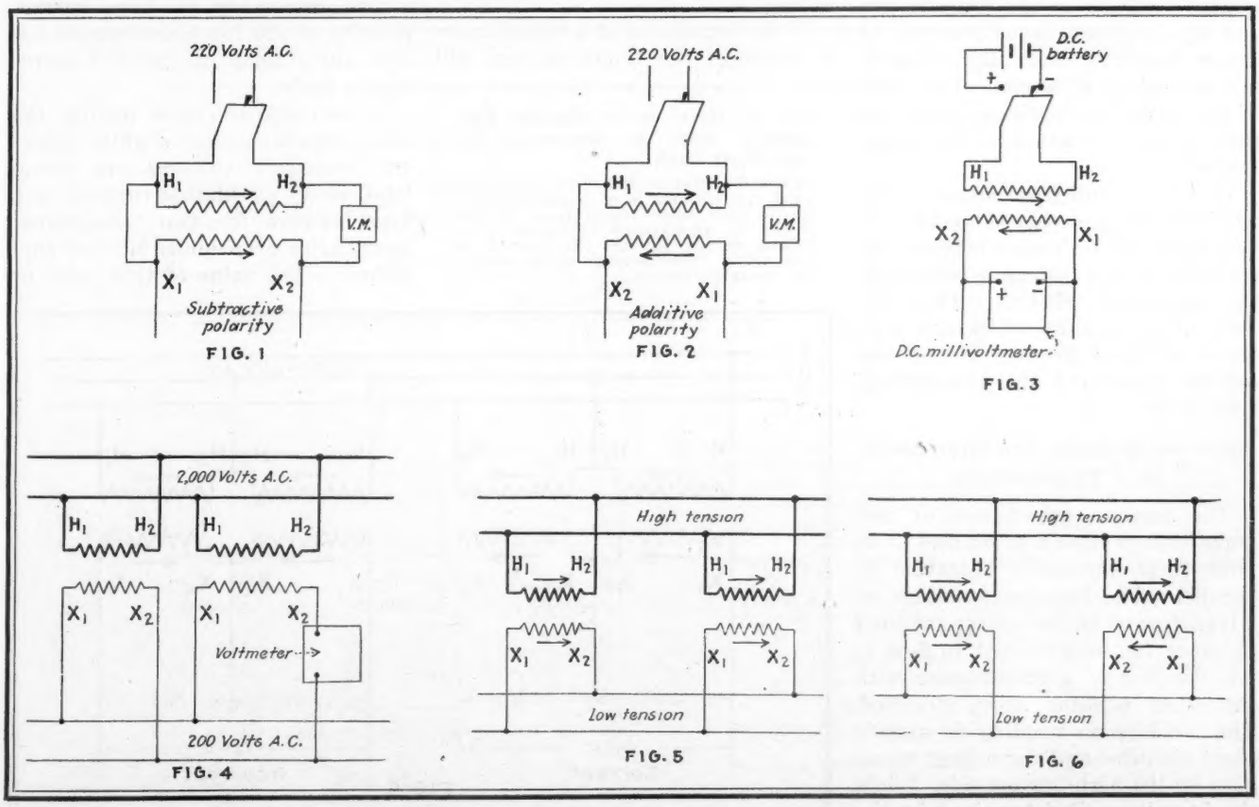
A better test can be made in the following manner: At any place where there is an alternating-current supply of the same frequency as the transformer under test, connect the high- and low-tension windings, as shown in Fig. 1, by an insulated wire so that the high-tension lead on one side of the transformer is tied to the low-tension lead on the same side of the case. Have all leads free from ground and not touching. Now apply a voltage of 110 or 220 volts to the high-tension winding. Be sure to apply this voltage to the proper winding. Then connect a voltmeter, having a full-scale reading approximately fifty volts higher than the voltage of the test line, across the unconnected high-tension and low-tension leads as shown in Fig. 1. If the voltmeter reading is less than the voltage of the test circuit the instantaneous polarity is as shown by the arrows in Fig. 1 and the transformer is said to have subtractive polarity. The subtractive action is caused by the voltage induced in the low-tension winding opposing the current trying to flow through the voltmeter from the two high-tension leads. If the voltmeter reading is higher than the line voltage, the polarity is as shown in Fig. 2 and the transformer is said to have additive polarity. This is due to the fact that the induced voltage in the low-tension winding aids the voltmeter current. Unless the line voltage used for testing is very steady, it is usually best to perform this test with two voltmeters, using one as shown in Fig. 1 and connecting the other across the source of power supply.

Another way of testing the polarity of a transformer is to use a small storage battery and a millivoltmeter of 500-millivolts range. Connect the storage battery to the high-tension winding of the transformer as is shown in Fig. 3. The millivoltmeter should be connected as shown in Fig. 3, with its positive terminal connected to the low-tension lead that is on the same side of the transformer as is the high-tension lead that is connected to the positive side of the storage battery. The high-tension side should be connected through a switch to the storage battery. On closing the switch the millivoltmeter will give a small deflection. If the needle is thrown up scale then the current flow and polarity of the two windings are as shown in Fig. 3; that is, the transformer will have additive polarity.

The flow of current in the primary winding is determined from the polarity of the battery and is as shown by the arrow. The flow in the secondary must be as shown by the other arrow if the millivoltmeter reads up. This then means that when current is entering the primary through the left-hand lead, it is leaving the secondary over the left-hand secondary lead at the same instant.

Great care must be used to see that the millivoltmeter is disconnected from the secondary winding before the battery switch is opened, as it would be ruined by the backkick from the winding. The switch should be opened as soon as possible in order not to allow the current to build up to any higher value than

Figs. 1 to 6—Methods of testing for polarity and how to parallel transformers of opposite polarity. In Fig. 1 two adjacent high- and low-tension terminals, H_1 and X_1 are connected together and a voltmeter is connected to the other two adjacent terminals, H_2 and X_2. The 220-volt alternating-current power is applied to the high-tension winding as shown. If the voltage measured on the voltmeter is less than the voltage applied to the high-tension winding the transformer has subtractive polarity, as shown in Fig. 1. If the voltage reading is greater than the supply voltage, the transformer has additive polarity, as shown in Fig. 2. In Fig. 3 is shown another method of testing for polarity by using a storage battery and a direct-current millivoltmeter. In paralleling two single-phase transformers the connections should be made as shown in Fig. 4. If the voltmeter reads zero the voltmeter may be removed and the connection completed. Figs. 5 and 6 show the connections for paralleling two single-phase transformers having the same polarity and also the connections for paralleling them if they have opposite polarities.



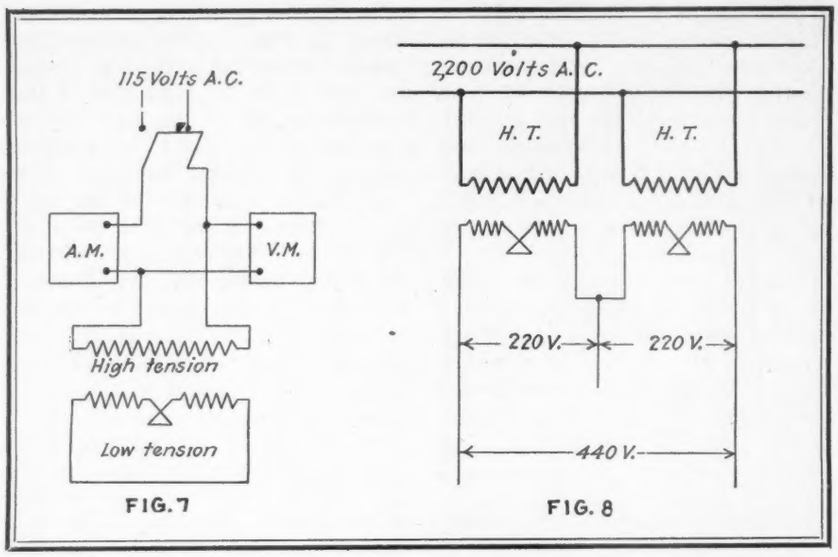


FIG. 7 FIG. 8

Figs. 7 and 8—Method of measuring impedance of transformers.
In Fig. 7 the impedance of the transformer is being measured by shorting the low-tension winding and applying 115 volts alternating current to the high-tension winding, at the same time measuring the current and voltage impressed on the high-tension winding. The voltage divided by the current gives the ohms impedance. Fig. 8 shows an arrangement for connecting two transformers to obtain twice the secondary voltage that would be obtained if the secondary windings were connected in parallel.

necessary as the switch will draw an arc on being opened.

Value of Making Ratio Test on Transformers

The ratio test is of value in determining whether the various taps are properly made. Where transformers are to be operated in parallel it is well to make a check on the voltage ratio.

A simple way to do this if a low reading, alternating-current voltmeter is available, is to excite the high-tension winding from a 440-, 220-, or 110-volt power source of the same frequency as the transformer and obtain simultaneous readings of the voltmeters across the primary and secondary windings. The ratio of the voltmeter readings is then the ratio of transformation of the transformer.

If a low-reading voltmeter is not available this test may be made as in Fig. 2 and the difference between the readings is the voltage produced by the secondary winding. Then the ratio of the reading of the line voltmeter to the difference of the two meters represents the transformation ratio.

How to Measure the Impedance of a Transformer

The relative impedances of two transformers have a great deal to do with their successful operation in parallel. The impedance voltage of a transformer is the voltage required to cause full-load current to flow in one winding of a transformer with the other winding short circuited. The low-tension winding is usually short circuited and the voltage measured on the high-tension side. While the impedance is determined by the voltage required to force full-load current through the transformer with the low-tension winding shorted, it is usually expressed as a percentage of the normal, high-tension voltage.

If the impedance of a transformer is unknown the following test will determine it. The secondary leads of the transformer are bolted together, making a good electrical connection. An ammeter is placed in series with the high-tension winding and a voltmeter is connected in as shown in Fig. 7. The range of the ammeter will depend upon the impedance ohms of the transformers; for the smaller transformers, a meter of one or two amperes range will be sufficient when testing with 115-volt power supply of the same frequency as the transformer. Power is applied to the arrangement shown in Fig. 7 and simultaneous readings are taken of the ammeter and voltmeter.

Assume that the transformer under test is rated at 75 kva., 12,000/440 volts, 60 cycles, 6.5 amp., full-load current. On making the test shown in Fig. 7, the readings of the meters were 115 volts and 1 amp. Then, impedance volts = (full-load current $\times$ volts read) $\div$ current read = $(6.5 \times 115) \div 1 = 718.75$.

The impedance, however, is usually expressed as a percentage of the normal high-tension voltage; hence the per cent impedance equals $(718.75 \div 12{,}000) \times 100 = 5.99$ per cent.

Effect of Characteristics on Parallel Operation

The two chief characteristics affecting parallel operation are voltage ratio and impedance. It is, of course, necessary to have correct polarity of the two transformers before any attempt at parallel operation is made.

If two transformers having the same impedance, but slightly different secondary voltages are paralleled, heavy circulating currents will flow between the two transformer secondaries even under no-load conditions. The value of this cross or

Fig. 9—Here is a mistake frequently made in connecting an open-delta bank.
In the diagram on the right, the right-hand transformer is of opposite polarity to the other transformer in the bank. In consequence 189 volts is obtained across X_1 and X_3 instead of 110 volts. The remedy is to reverse the leads X_3 and X_4.

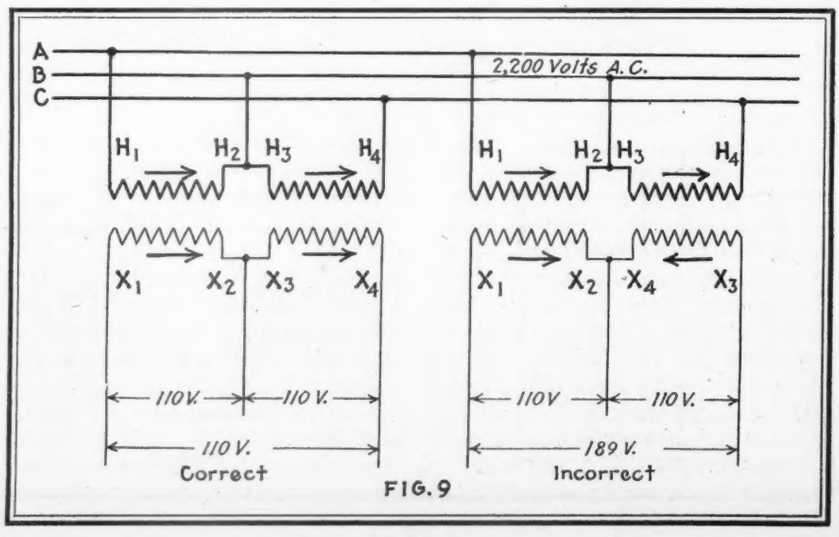


FIG. 9

circulating current may be determined from the following formula: Per cent full-load current = difference in secondary voltage × 100 ÷ sum of impedance volts of each winding.

The impedance volts is the voltage required to force full-load current through the high-tension winding when the secondary winding is short circuited. The voltage difference and impedance voltage used in the above formula must all be referred to the same winding.

In Fig. 4 let us assume that each transformer is rated at 200 kva., 2000/200 volts, impedance of each transformer equals 10.5 volts referred to secondary winding or 5.25 per cent. With the transformers connected as shown, assume that the voltmeter reads 21 volts, indicating that there is a difference of 21 volts between the secondaries of the two transformers. Substituting in the formula given we find that the per cent of full-load current that will circulate between the two transformers equals (21 × 100) ÷ (10.5 + 10.5) = 100 per cent. Consequently the transformers would overheat badly if an external load equal to their rating were applied.

Fig. 4 shows the manner in which the secondary voltage should be tested before paralleling. The voltmeter should read zero in order to obtain the best operating conditions. The voltmeter used should be of double the range of the voltage of one transformer, for if the polarities of the windings are not alike the voltage will be double the rating of the one transformer. This test indicates the polarity as well as the voltage difference of the two secondary windings of the transformers tested.

An ammeter or a current transformer and ammeter may be inserted in the leads to determine any circulating current at no load. It is always best to measure the load on two transformers placed in parallel to be sure that each is carrying its proper load. An open fuse or loose connection in one transformer might throw all the load on the other.

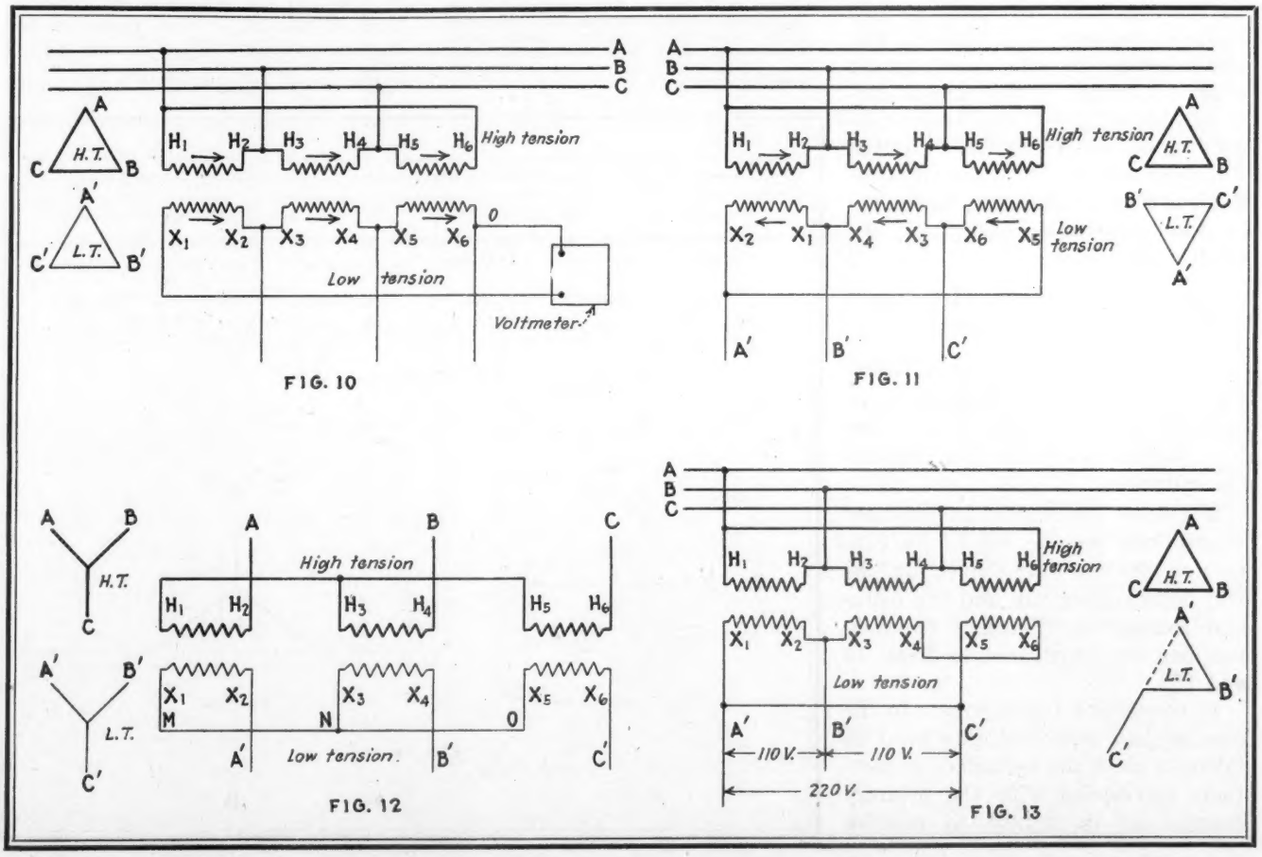
If two transformers of the same rating have the same secondary voltage but do not have the same per cent impedance, they will not divide their loads properly. A 1,500-kva. transformer of 2.5 per cent impedance was to operate in parallel with a 3,000-kva. transformer of 5 per cent impedance. In order to prevent the smaller transformer from overheating due to carrying too heavy a load, because of the difference in impedance, it was necessary to insert reactors in series with the 1,500-kva. transformer so that its total impedance equalled 5 per cent. The load division then was in proportion to the transformer ratings.

If the impedance difference is not too great, it may be compensated for by a change in the voltage taps. The transformer having the lower impedance should have a lower secondary voltage.

From the foregoing it is seen that

Figs. 10 to 13—Methods of testing connections of three single-phase transformers which are to be connected to form a bank.

In Fig. 10 the transformers are connected delta delta. In testing, the high-tension connections are completed as shown and the low-tension connection between X_2 and X_3 is made. For the arrangement to be correct, a voltmeter connected across X_1 and X_4 should show the same voltage as across the low-tension winding of one transformer. The connection between X_4 and X_5 is then made and if the voltmeter, connected as shown in the diagram, reads zero, the connections are correct. At the left is shown the relation between the voltages of the transformer bank. Fig. 11 shows the same connection as Fig. 10 but the transformers have the opposite polarity as is shown by the marking of the transformer leads and by the voltage diagram shown at the right. In making a delta-delta connection it is possible to make an error in connecting the transformers and thus have one transformer with reversed polarity. This is shown in Fig. 13. In Fig. 12 is shown a star-star connection. In testing, the high-tension connections should all be made as shown and the low-tension connection between X_1 and X_3 should be completed. For the connection to be correct, the voltage across X_2 and X_4 should be 1.73 times the low-tension voltage of one transformer, that is, across X_3 and X_4. X_3 is then connected to X_5 and the test repeated.



in order to parallel two transformers it is necessary that the polarity be correct, that the voltage ratio be the same, and that the per cent impedance of the transformers be equal.

Transformer Connections for Single-Phase Service

Single-phase transformers may be connected for single-phase transformation or in banks for three-phase operation. Many interesting combinations of connections may be obtained with both single-phase and polyphase connections.

Fig. 5 shows two single-phase transformers of the same polarity correctly connected in parallel. Fig. 6 shows two single-phase transformers of different polarity connected in parallel.

A connection which is often of service is shown in Fig. 8. With this arrangement are used two transformers having their primaries connected in parallel and their secondaries connected in series. By this arrangement twice the secondary voltage is secured that would be obtained if the secondary windings were connected in parallel as usual. In this manner, 440 volts may be obtained in an emergency when only 220-volt transformers are at hand. By using different-ratio transformers with this connection other voltages can be obtained. It makes a very good emergency connection. The load carried by the combination would be limited to the current-carrying capacity of the secondary winding of one transformer. If the transformers are of different sizes the load should, of course, be limited to the carrying capacity of the smaller transformer.

Transformer Connections for Three-Phase Service

In connecting single-phase transformers in banks for polyphase operation, it is necessary to consider the characteristics of the various transformers.

The usual three-phase transformer connections are the delta-delta connection, the star-star connection, the star-delta connection, and the delta-star connection. The first two connections are illustrated in Figs. 10 and 12.

In connecting transformers in the manner just described, care must be taken to make the secondary connections correspond with the primary connections in regard to relative polarities and phase rotation. If this is not done a short circuit may be caused with delta-connected secondary windings and incorrect voltages may be obtained with star-connected secondary windings. It is assumed, of course, that the transformers are all of the same ratio.

If the primary and secondary windings of the bank of transformers are both to be connected delta or star, it is an easy matter to get the connections right. After the primary leads have been connected up, test the secondary winding of each transformer to make sure they have the same polarity. Then connect the secondary leads from the three transformers exactly as the primary leads have been connected. If the transformers do not have the same polarities follow the instructions given in the following paragraphs.

If the primary and secondary are not to be connected in the same manner, that is, if one is to be connected delta and the other star or *vice versa*, the method just outlined cannot be applied, because of the difference between star and delta connections. In such cases, the primary windings should be connected up in the manner in which they are to be operated and the secondary connections tested out as follows.

For delta-connected secondary windings, connect two secondaries together as shown in Fig. 10, that is connect X_2 of the left-hand transformer to X_3 of the center transformer. The connections between X_4 and X_5 and at O are to be left open for the time being. Now measure the voltage from X_1 of the left-hand transformer to X_4 of the center transformer. It should equal the voltage measured across X_1 and X_2 or across X_3 and X_4. If it does the connection is correct. If the voltage across X_1 and X_4 is about 1¾ times the voltage of one transformer, reverse the secondary of either transformer, to correct that condition.

After having obtained the correct voltage between X_1 and X_4, connect X_4 to X_5 and measure the voltage between X_1 and X_6 as shown in Fig. 10. If the connection is right the voltage should equal zero. If the voltage is about twice the voltage of one transformer, the secondary of the third transformer should be reversed.

For star-connected, secondary windings connect X_1 to X_3 as shown in Fig. 12, leaving open the connection shown at O and measure the voltage across X_2 and X_4. It should equal about 1¾ (exactly 1.73) times

Fig. 14—Transformer banks having dissimilar connections should not be paralleled.

The diagram shows a delta-delta connected bank at the left arranged to be paralleled with the star-delta connected bank shown at the right. These banks will not parallel, due to their voltages being out of phase as is shown in the voltage diagrams.

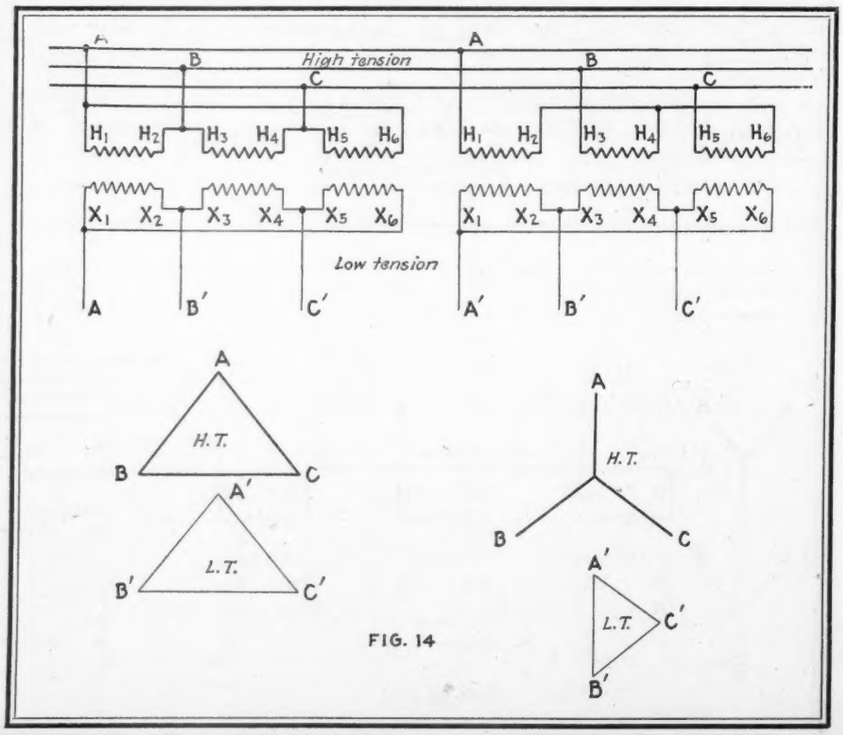


FIG. 14

the voltage across one transformer that is across X_1 and X_2. If the voltage measured across X_2 and X_4 should equal the voltage across one transformer, one of the secondaries must be reversed; that is X_4 must connect to X_1, and X_2 and X_3 will become the line wires.

After the first two transformers have been properly connected, one lead of the third transformer should be connected to the common wire of the other two transformers; that is X_5 of the third transformer should be connected to the wire connecting to X_1 and X_3 as shown in Fig. 12. The voltage measured between X_5 and X_4 or between X_6 and X_2 should be about 1¾ times the voltage of one transformer. If the voltage measured is equal to the voltage of one transformer then the connection of the third transformer is wrong, and the secondary of the third transformer must be reversed.

A connection using transformers of opposite polarity is shown in Fig. 11. The difference in the vectors of the secondaries should be noted. It will be seen that these two secondaries have the same phase angle but not the same polarity. In making a delta-delta connection it is possible to make an error in connecting and thus have one transformer in the bank with reversed polarity. This condition is illustrated in Fig. 13 and if the bank were thrown on the line a very heavy, circulating current would flow which would blow the fuses or open the oil switch. This emphasizes the necessity of checking (as indicated in Fig. 10) the last connection of the delta before completing the connection.

Three-phase current may be supplied by the use of only two single-phase transformers connected in open delta. In connecting two transformers in open delta, it is necessary to observe the polarity closely, particularly if transformers of different makes are used. This is shown in Fig. 9. It is possible to have nearly double voltage on one phase, due to incorrect connection. It should be observed that two transformers operating in open delta have only 86.6 per cent of the combined kva. rating of the two transformers. They should be loaded accordingly.

In paralleling banks of transformers, the individual units must have the same ratio, polarity and per cent impedance and must also be similarly connected; that is, a delta-delta connected bank cannot be paralleled with a star-delta connected bank, but should be paralleled with a delta-delta connected bank.

The effect of the method of connecting the transformers is very plainly shown by the connections in Fig. 14. Here are a bank connected delta delta and a bank connected star delta. The vector diagrams plainly contrast the difference in the phase angle of the two secondaries although the polarities of the secondaries are the same. The secondaries of these transformers could not be paralleled due to this angularity of 30 deg.

The two banks shown in Figs. 10 and 11 are of opposite polarity as can be seen by the arrows in the diagrams and by the voltage diagrams beside each figure. The secondary voltages of these two banks are 180 deg. out of phase and, therefore, they cannot be paralleled.

It is, then, a wise precaution to check up the relative polarity of the two banks of transformers before paralleling them. This may be done by connecting both banks of transformers on the high-tension side to the power supply. The low-tension sides of both banks are connected up as they are intended to operate but all of the parallel connections between the transformers should not be closed. One terminal only of each bank is connected to one of the common bus bars or parallel connections. Then the voltage is measured from each of the other terminals of one bank to the corresponding terminal of the other. If the polarities are alike the voltage will be zero. If the polarities are reversed, the voltmeter will read double the secondary voltage in each case. The remedy is to reverse (*Continued on page 602*)

Figs. 15 to 17—Method of testing three-phase transformers for parallel operation.

In Fig. 15 the high-tension sides of both transformers are connected to the power supply after one low-tension terminal of each transformer has been connected as shown. For the transformers to parallel correctly the voltages across *M* and *N* and across *O* and *P* should be zero. Figs. 16 and 17 show the effect of a transposition of low-tension leads in a three-phase transformer. Fig. 16 shows the way the connections were given on the nameplate of the transformer. Fig. 17 shows the way they were actually found. The voltage diagrams shown below each figure give the voltage relations. As can be seen, phases B^1 and C^1 would have to be interchanged on the low-tension side for parallel operation.

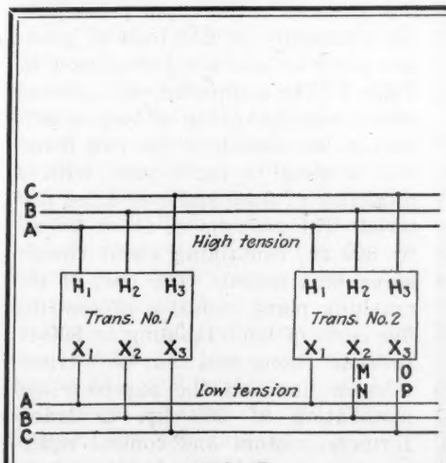


FIG. 15

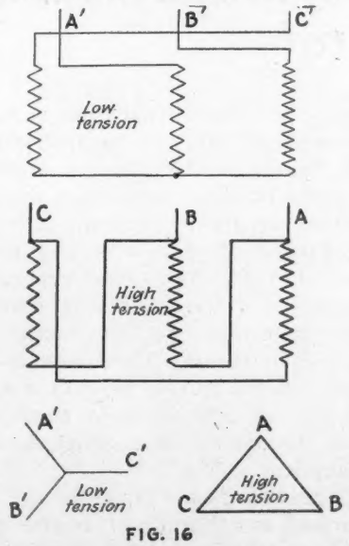


FIG. 16

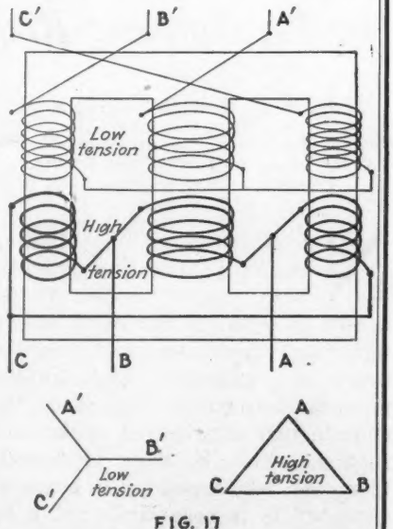
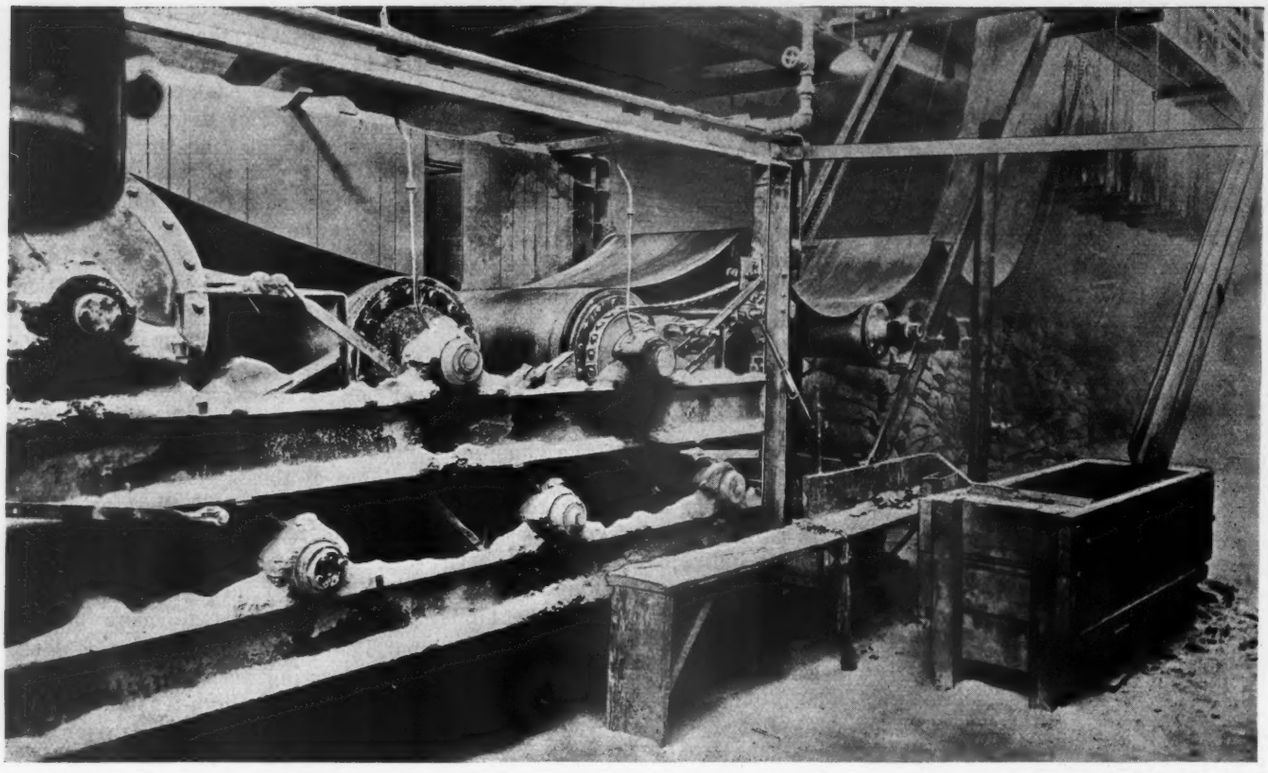


FIG. 17



This shows the coated felt passing from the water-cooled cooling cylinders to storage on the stick-type looper shown in Fig. 1 on the next page.

Some Relations Between

Maintenance and Operating Costs

In the Manufacture of Prepared Roofing Together with Details of Production and the Equipment Required

By J. L. McK. YARDLEY

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NO BRANCH of the building supply industry provides more opportunity for studies in raw material procurement, manufacturing operations and maintenance of equipment, and finished product distribution than does the manufacture of prepared or surfaced roofing, which is made principally from rag felt, asphalt and granular slate. This is necessarily not a localized industry. In fact, it is most successfully conducted when its national, or international scope is fully recognized. While in its application and selling ramifications it extends into the building industry in the remotest corners of the country, in its production it associates and links several of the world's most important industries while combining diverse raw materials. In the process involved in turning these raw materials into the finished product, a wide variety of equipment is employed, and the maintenance problems are many and varied.

Granulated slate is one of the important constituents of roofing and it is usually preferable to mine the rock rather than quarry it, so as to insure that it will be perfectly dry. Here is a crushing problem in which fine grinding is not desired. The granules must be uniform. Tests on samples of Vermont granules indicated that by weight 66 per cent of the product goes through No. 10 mesh and on to No. 20; 23 per cent goes through No. 20 mesh and on to No. 30, and 11 per cent goes through No. 30 mesh. The detailed construction costs of a Michigan plant having a capacity of 240 tons of granules per 8-hr. day are given below in Table I. The equipment was selected with a view to having as large a percentage as possible of the raw material crushed to exact size, with a minimum of fines and over-sized material. The property of about 400 ft. by 800 ft., containing about twenty acres, was leased. The cost of the crushing plant inclusive of clearing five acres of land, building an 800-ft. railroad siding and four-mile transmission line and the purchase and installation of 600 hp. in transformers, motors and control equipment amounted to almost exactly $150,000.

This plant took a 15-min. peak load as well as an average of 450 kw. for the 8-hr. day at a cost of approximately 2.53 cents per kw.-hr., making

a power cost of about 40 cents per ton. The material would be shipped at approximately $1 per ton, including labor and overhead.

An analysis indicated that a fuel-oil-engine power plant would have a total installation cost of $100,000 and a total yearly operating cost of $30,300 or 2.81 cents per kw.-hr. A steam turbo-generator power plant would have a total installation cost of $95,210 and a total annual operating cost of $31,877 or 2.95 cents per kw.-hr. It would also require about 1,000 gal. of water per minute for boiler feed and condensation purposes. It was accordingly found economical to purchase power, particularly as the power company agreed to return $6,500 by deductions from power bills.

Table I—Construction Cost of Slate Granulating Mill

Item	Cost
Railroad siding, 800 ft. at $50 per ft	$ 4,000.00
Clearing five acres of land at $200 per acre	1,000.00
Construction of 4-mile transmission line, erection of transformers	8,000.00
Cutting away rock from hill for mill site at $50 per yd	1,000.00
Well, 50 ft. deep, for drills, buildings and heating boiler	500.00
Telephone installation	100.00
Machinery complete	60,000.00
Motors and starters, 600 hp. at $25 per hp.	15,000.00
Installation of machinery and motors	8,000.00
Mill building, including lighting system	10,000.00
Combination office, supply room, first aid dept. and home	4,000.00
Equipment for combination office	2,000.00
Machine shop building	1,500.00
Machine shop equipment	5,000.00
Change house and equipment for workmen	5,000.00
Heating system and plant	3,000.00
Concrete foundations	2,000.00
Powder storage shed	600.00
Storage bins, material and labor	6,000.00
Transformer station	3,300.00
Plans, designs, specifications, engineering and construction supervision	10,000.00
Total	$150,000.00

Equipment and Operation of Roofing Felt Mill

The manufacture of felt is similar to the manufacture of paper, where cylinder-type machines are employed. The class of labor is the same and in general the machinery employed is the same as in the board mill. The felt machine usually employed produces a roll 72 in. wide, which is slit into two rolls 36 in. wide. One difference is that the pulp mill and the extensive use of power in this industry is done away with, as the raw rag material does not require grinding, although it does require cutting into shreds and the cutter is the first machine the rags encounter in the flow sheet as they leave the rag storage. There are, of course, modifications due to local conditions but, in general, all felt mills are about the same.

The usual felt mill is exceedingly inefficient in the use of power and steam. Felt mills are generally self-contained; that is, they generate the power which is required, and largely as a by-product in obtaining the steam which is required in drying. This is a problem which is susceptible of being worked out very nicely through the application of proper engineering principles.

There is need for good consulting engineering in this industry and competition will probably make this still more apparent in the future. Some of the best mills produce a little more than a pound of felt for each pound of coal burned. Others which I have known are woefully inefficient, requiring two pounds of coal per pound of felt. The reason for such a discrepancy is that the cost of power and steam, even when inefficiently used in the self-contained mill, is still but a small part of the total cost of manufacture of felt. This is shown by the cost analysis given in Table II of a week's operation of a three-machine mill having a capacity of about seventy-five tons of felt per day and an over-all valuation of approximately $1,000,000. Such analyses probably explain why power and steam losses have not been determined and corrected to the same extent that they have been in the paper-making industry, for example. It will also be seen from this table that the cost of maintenance and repairs is by far the largest item of expense for the total non-productive labor.

Of the total of $2,135.62 for non-productive labor, $1,747.55, or 81.8 per cent, was spent for repairs and

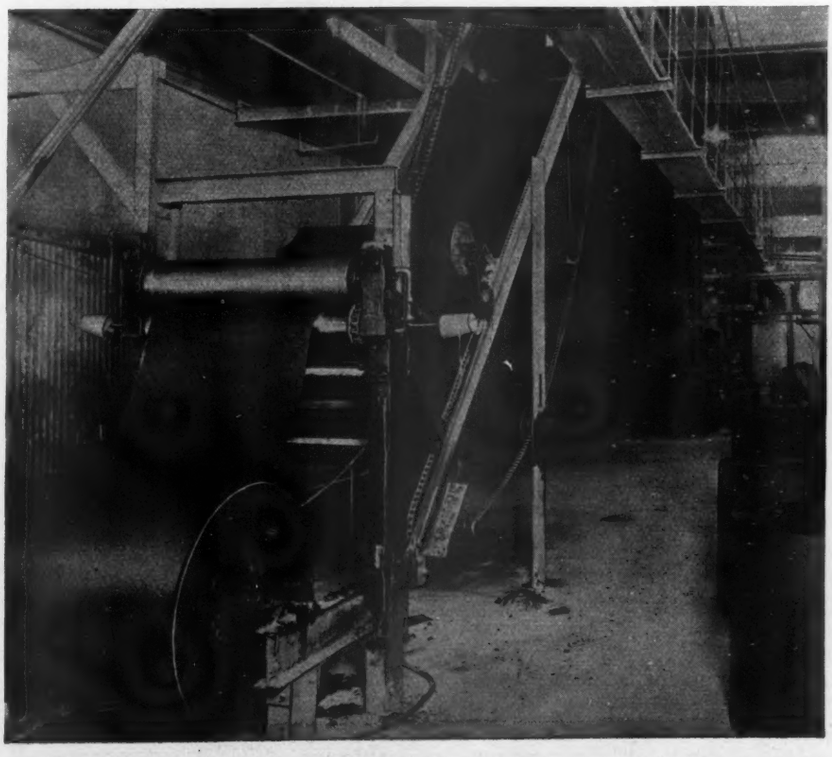


Fig. 1—Stick-type looper for cooling felt after saturation in roofing machine.

In addition to cooling the felt this type of looper compensates for irregularities in the rate of production. As shown here the felt is being wound on a reel after passing through pull rolls.

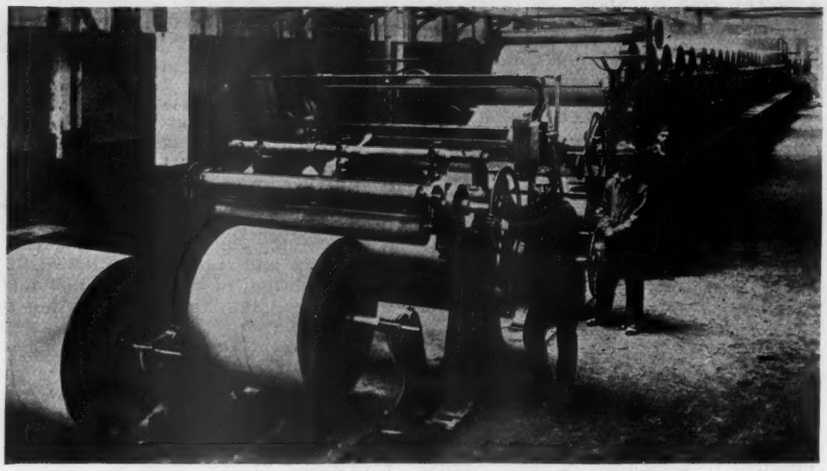


Fig. 2—Finishing end of felt making machine, showing steam heated drying cylinders, which put the felt in condition for saturating.

maintenance of equipment and buildings. This table is typical, although it covers a high-cost period during 1920 at which time a roofing plant on the Pacific Coast paid anywhere from $126 to $146 per ton for felt locally produced and from $150 to $185 per ton for Eastern felt. The Eastern felt included nearly $25 freight to San Francisco and the Western felt, $5.50 from Los Angeles or $1 from local source. A profit of $50 per ton for an output of seventy-five tons per day, means a total profit of more than $1,000,000 per year for the felt mill.

Layout and Operation of the Roofing Mill

The layout of the roofing mill is of the utmost importance from a production point of view. Here the problem is to maintain and deliver a water-free felt to the saturating machine, saturate it and coat it with asphalt and an even layer of slate granules at a high temperature, cool it and wind it into rolls or cut it into shingles for shipment. The total amount of power employed is small, being in the neighborhood of 60 hp. for a continuous saturating, coating and shingle-cutting unit. About 35 hp. are required for the saturating and coating machines and cooling rolls, 10 hp. for the cutters and 10 hp. for the dryers when used in advance of the saturating machine, and for the beginning rolls. Whereas in the felt mill the cylinders filled with steam were used to dry out moisture, in the roofing mill the usual function of the cylinders is to cool and harden the saturated and coated felt before it is rolled or cut into shingles, and for this purpose they are supplied with a constant stream of cool water. Usually, however, the cylinder coolers are supplemented or often largely supplanted by stick-type looper coolers such as shown in Fig. 1.

The biggest machine output is obtained by entirely separating the saturating and coating processes. Splices may be made after the felt has been saturated. Spraying of the saturant on the felt is being considered, although the usual method is to run the felt through a tank of saturant maintained at a suitable temperature by heating coils. The saturant temperature employed varies from 420 deg. F. to 350 deg. F. The latter is best practice, in which case two saturating machines are used for one coating machine. As a coating temperature of 360 deg. F. to 370 deg. F. is maintained by steam coils in the tank cars, high-pressure steam, above 150 lb. is necessary. The stick-type looper is generally considered the best. It should be of ample capacity, particularly where located between saturating and coating machines in a continuous unit, for the purpose of preventing momentary troubles at one machine reducing the production of the other. A preferred layout would include:

FORM 534 SM 8-16-20

PLANT .....

DAILY MACHINE REPORT

[redacted] ROOFING COMPANY

MACHINE NO. ..... DATE .....

KIND OF ROOFING	PLY	PRODUCTION: SNGL. SQS. FIRSTS	SNGL. SQS. SEC.	SQS. OF 108 SQ. FT. FIRSTS	SQS. OF 108 SQ. FT. SEC.	SQS. OF 108 SQ. FT. THDS	Av. TONS PER HR.	HOURS OPERATED	ACTLY RUN G	TIME LOST	REASON (GIVE NO.)	WT. PER SQUARE	TOTAL WEIGHT
TOTALS													

ACCOUNT FOR DELAYS AND TIME LOST IN SPACES PROVIDED BELOW:

	Felt Troubles.	Broke where?	Minutes
1	Breaks Holes in felt		
2	" Crushed felt		
3	" Broken torn edges		
4	" Thin spots		
5	" Not strong enough		
6	" Poor splices		
7	" Wet felt		
8	"		
9	"		
10			
11			
12			
13			
14			
15			
		Total	

MECHANICAL	Min.	GENERAL	Min.
16 Belt and drives		31 Pumping back	
17 Motors and electrical		32 Waiting for set.	
18 Hoppers		33 " " coating	
19 Pumps		34 Cold saturation	
20 Winders		35 " coating	
21 Clutches		36 Changing over	
22 Elevators		37 Coating lines plugged	
23 Slitters		38 No power	
24 Shingle Machine		39 Steam rolls	
25		40	
26		41	
27		42	
28		43	
Total		Total	

Felt Waste

Dry	.....lbs.
Saturated	.....lbs.
Coated	.....lbs.
Finished	.....lbs.
Total	.....lbs.

Daily operation	.....hrs.
Less time lost	.....hrs.
Actual day's run	.....hrs.

REMARKS:

SIGNED .....

MACHINE FOREMAN

Fig. 3—This machine report gives a complete record of the operation of a roofing mill.

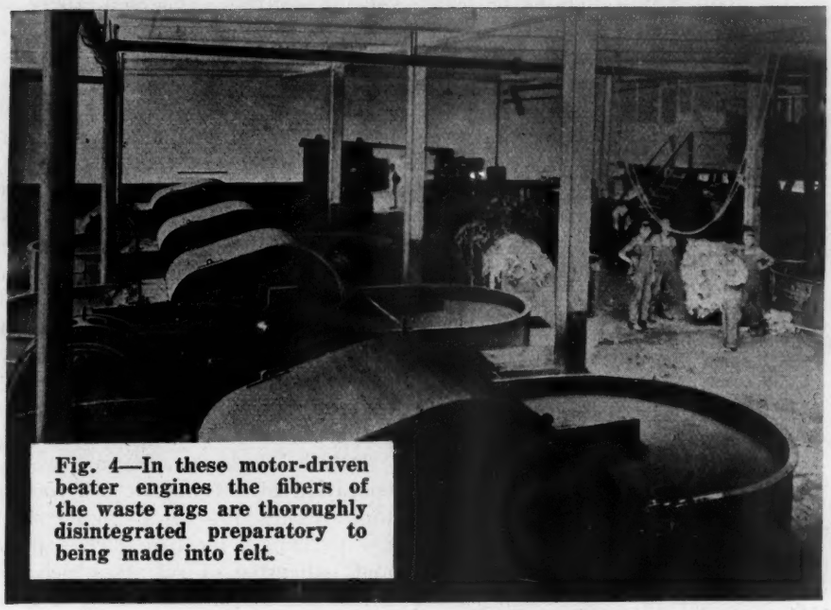


Fig. 4—In these motor-driven beater engines the fibers of the waste rags are thoroughly disintegrated preparatory to being made into felt.

(1) A looper for dry felt.
(2) A simple saturating section and reel winder for saturating felt.
(3) A conveyor so that a series of reels may be carried and set up in place for the coating section.
(4) A coating section with another looper.
(5) A simple set of coating rolls, probably two, and means for distributing slate evenly upon the coating.
(6) A stick looper with squeeze rolls installed in place for embedding the slate.

This equipment if installed on sound foundations with everything of the best should have an output for a single width machine of 300 squares of slate-surfaced roofing or 400 squares of smooth surfaced roofing per hour. A "square" is roofing sufficient for 100 sq. ft. of roof surface. At about 85 lb. for the one or 55 lb. for the other, this represents an output of about 12 tons per hour. When manufactured into shingles at the usual 240 lb. per square, the output per hour is slightly over 100 squares. These are usually shipped in four packages to the square. A daily machine report form covering the operations of the roofing mill is shown in Fig. 3.

Equipment Required in Roofing-Asphalt Refinery

The hourly output of one machine making slate-surfaced roofing will require approximately 3 tons of granules, 3 tons of felt and 6 tons of saturant and coating. These figures give a rough idea of the production demand upon the granulating mill, felt mill and refinery.

The industrial use of asphalt is growing rapidly. In the roofing trade particularly, all guaranteed and first-grade roofing is made of prepared felts saturated and coated with asphalt. In the saturation process use is made of an asphalt which is soft enough to impregnate the felt without excess, and a hard, high-melting point material is used as a coating, to protect against abrasion and weathering. The saturant is obtained by distilling crude petroleum and the coating is obtained from the impregnating asphalt, by a further process of oxidation, either by a vacuum system or by blowing at high temperatures. The product is spoken of as a blown asphalt. The effect of the blowing or oxidizing treatment is to produce a coating material which may be looked upon as dehydrogenated and condensed, so far as its molecular structure is concerned. This operation may be performed at the refinery and the blown asphalt shipped in drums. Coating obtained and shipped in this manner from an uncontrolled source has been about

Table II—Operating Expenses of Felt Mill for One Week

During this period there were 176 employees, and 398 tons of felt were produced.

Productive Labor

	Operation	Total		Per Ton	
1.	Sorting and cutting	$ 702.90		$1.77	
2.	Beater men	1,233.22		3.10	
3.	Trucking—beater room	145.20		.36	
4.	Machine tenders	578.63		1.45	
5.	Cleaning and oiling	56.65		.14	
6.	Testing and winding rolls	180.58		.45	
7.	Receiving rags	400.72		1.01	
8.	Receiving paper	34.10		.09	
9.	Receiving coal	72.74		.18	
			$3,404.74		$ 8.55

Non-Productive Labor

10.	Repairs, rag cutting machines	$ 115.50		$0.29	
11.	Grinders, cutting knives	31.24		.08	
12.	Repairs to paper beaters	7.62		.02	
13.	Repairs to rag beaters	111.16		.28	
14.	Repairs to chests	67.60		.17	
15.	Repairs to Jordans	1.66		.005	
16.	Repairs to sundry equipment	113.72		.29	
17.	Repairs to No. 1 machine	58.97		.15	
18.	Repairs to No. 2 machine	51.91		.13	
19.	Repairs to No. 3 machine	42.38		.11	
20.	Repairs to machine room equipment	12.18		.03	
21.	Engineer and fireman	431.50		1.08	
22.	Repairs to boilers	5.94		.015	
23.	Repairs to stokers	5.54		.015	
24.	Repairs to boiler house equipment	273.82		.685	
25.	Repairs to pumps	90.54		.23	
26.	Repairs to electrical equipment	58.08		.14	
27.	Repairs to motors	27.08		.07	
28.	Repairs to water tower	6.30		.02	
29.	Repairs to locomotive crane	63.05		.16	
30.	Repairs to machine shop equipment	4.56		.01	
31.	Repairs to machine rooms	148.80		.37	
32.	Shipping labor	151.55		.38	
33.	Watchmen and janitors	57.30		.14	
34.	Drivers	127.63		.32	
35.	Miscellaneous building repair	21.40		.05	
36.	Miscellaneous expense	51.59		.13	
			$2,135.62		$ 5.37
	Grand total labor		$5,540.36		$13.92
	Cost of rags at platform				78.00
	Cost of coal, two tons per ton of felt at approx. $4.00				8.00
	Total cost of felt per ton				$99.92

50 per cent more expensive than saturant. However, a number of roofing mills have found it preferable to avoid the expense of drums by shipping all asphalt as saturant and blowing the necessary coating at the roofing mill, making as large as possible a use of tank cars.

The industry practically justifies a refinery devoted primarily to its own requirements. In addition to the large tonnages of saturating and coating asphalt demanded, there is a large field for refinery distillate products in the manufacture of mastic cushions for roofing tile, roof repairing cements, and cold roof paints. These products are manufactured with very small labor cost. A Pacific Coast plant during 1920 with only five men in the paint factory and with suitable equipment in less than 4,000 sq. ft. of space had a monthly capacity of 12,000 gal. black, 5,000 gal. red, 5,000 gal. green and 8,000 gal. brown roofing paint, 15,000 gal. shingle stains, 8,000 gal. concrete paint and 40 tons of elastic cement.

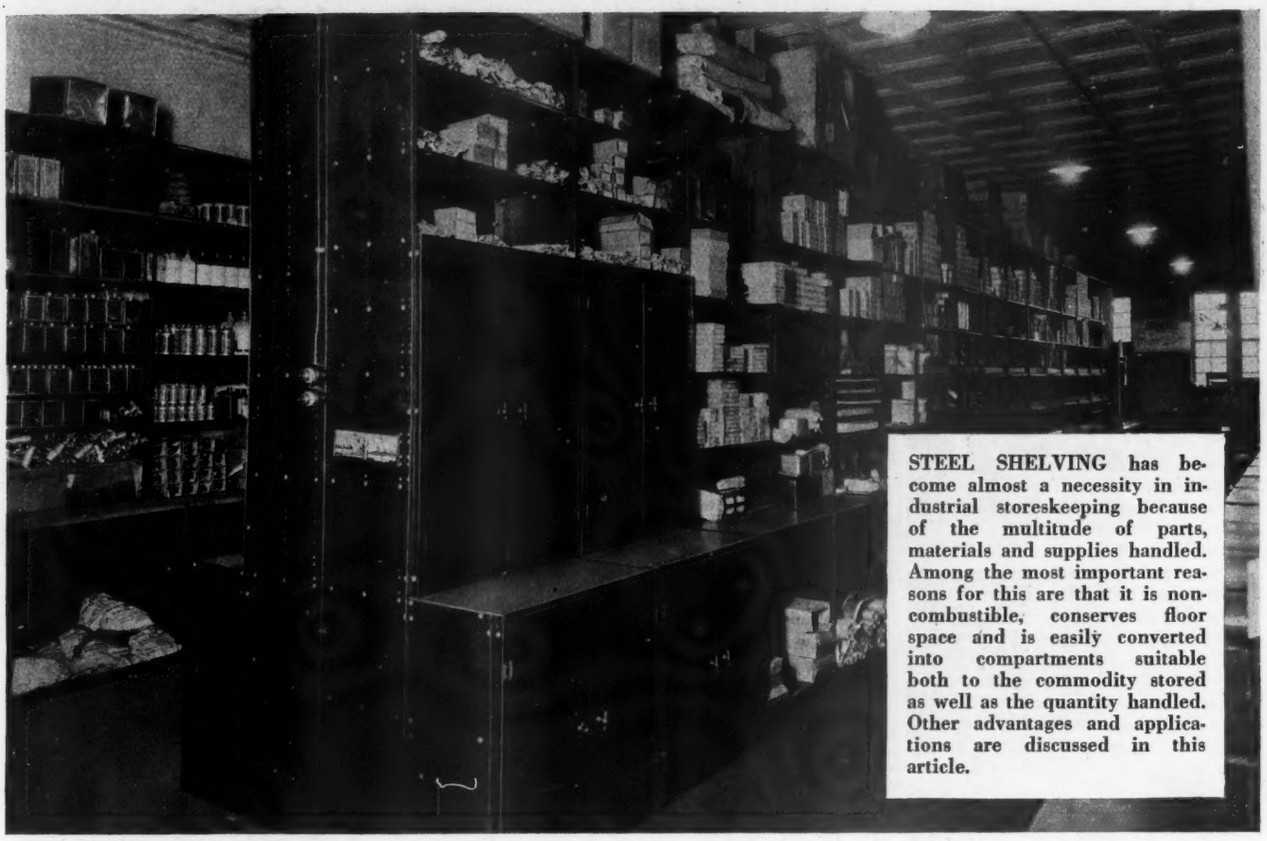
Detailed costs covering one week's operation of a four-machine roofing mill, disclosed several facts which are perhaps typical of such a plant and indicative of results which are sometimes obtained actually, as compared to what it appears might be obtained. The operation was one full shift for six days per week. Notable points are that for seventy machine-hours the machines were down because of no working orders; for one-fifth of the remaining available time, the machines did not deliver output owing to miscellaneous delays. The machines actually worked in production a total of only approximately 126½ machine-hours during the week. They produced in that time a total of 23,817 squares of smooth and slate-surfaced roofings, 9,038½ squares of which went into shingles. While producing their ouput was at the rate of only 188 squares per machine-hour and at a total labor cost of 24½ cents per square.

The cost of maintenance and repairs during this period is also of interest. Of a total of $5,840.11 chargeable to roofing production, $2,918.32, or approximately 50 per cent, was non-productive labor cost, such as yard labor, drivers' and chauffeurs' wages and so on. Of this non-productive labor, in turn $713.15, or 24 per cent, was charged to maintenance and repairs to buildings and equipment.

The amount and character of the equipment required for a crude petroleum refinery, for the roofing industry, with a yearly capacity of 1,138,800 bbl., is shown in Table III. This refinery was designed for a location on the lower Mississippi. It is laid out for the receipt and storage of crude oil from tankers and for the rail shipment of the refinery products. (*Continued on page 601*)

Table III—Estimated Cost of Equipment of Crude Petroleum Refinery for Roofing Industry

No.	Item	Cost
	Real Estate	$ 50,250.00
3	55,000 bbl. tanks, $25,000 each, $12,000 const.	111,000.00
3	12,000 bbl. tanks, 9,500 each, 3,400 const.	38,700.00
5	5,000 bbl. tanks, 4,900 each, 1,650 const.	32,750.00
2	2,000 bbl. tanks, 3,100 each, 950 const.	8,100.00
2	1,000 bbl. tanks, 2,000 each, 600 const.	5,200.00
1	60′x10′x4′ O. T. tanks, $2,200 each, $600 const.	2,800.00
1	6′x4′x4′ O. T. tanks	250.00
1	4′ dia., 6′ high x ½″	350.00
1	90′x40′x12 O. T. tank, $17,000 each, $4,000	21,000.00
2	30′x15′x12 O. T. tanks, 2,000 each, 600	5,200.00
1	Separator, $4,000 each, $1,200	5,200.00
6	Stills, 42′x14′6″, $7,000 each, $2,100	54,600.00
3	Stills, 30′x5′, $3,000 each, $750	11,250.00
1	Water tower, 50,000 gal.	12,000.00
3	350 hp. B. & W. boilers, $28 per hp., $15,000 each.	45,000.00
1	2,000 hp. Swartout boiler feed heater, $1,750, const. $422.	2,172.00
2	Foster super heaters, 10,000 lb. capacity, $4,700, const., $420, $2,000	11,820.00
26	Hammel fuel oil burners, $40.00 each	1,040.00
1	Hammel fuel oil set, 6x4x6	1,850.00
1	W. S. compound pot valve plunger pump, 14″x25″x10″x24″	10,500.00
4	W. S. piston pot valve pumps, 14″x10½″x18″, $2,500	10,000.00
2	W. S. piston box pumps, B. L. 14″x10½″x18″, $2,950	5,900.00
3	W. S. piston box pumps, B. L. 9″x7″x15″, $2,200	6,600.00
2	W. S. plunger pot valve pumps, B. L. 10″x7″x18″, $2,400.	4,800.00
1	Buffalo Underwriters fire pump, B. L. 18″x10″x12″	2,090.00
2	Box B. L. 7½″x6″x10″, $550.00	1,100.00
3	Kinney pumps, motor size 12-8-8, strainer, $2,662	7,986.00
2	Motor-driven water pumps	1,200.00
2	Motor-driven geared oil pumps for trap	1,200.00
6	3″ Fisher governors, $65.00	390.00
2	No. 4 P. H. & F. M. Roots gas exhausters	3,246.00
1	3-ton ice plant	
1	400′ wharf and approach	54,000.00
	Buildings complete	73,600.00
	Still and condenser foundations—brick work	38,850.00
	3,900 ft. switch track, $6.00 per ft.	23,400.00
2	10″ water wells	4,700.00
1	River water filter plant	4,450.00
	Lumber—form and scaffolding	1,850.00
	Pine	75,454.20
	Pipe fittings and pipe covering	44,463.76
46	"I" beams—15 lb. 40′ long, 77,280 lbs. at 5 cents lb.	3,864.00
	Steel stairways and walkways	1,052.00
	710 ft. Cyclone 7′ fence	1,313.50
2	200-kw. generators, turbine	22,600.00
1	Oil trap, 50′x20′	6,724.00
	Electric light and motor installation	11,797.00
2	Air compressors	10,000.00
2	Radial brick stacks, 125′x90″ at $8,724	17,448.00
	Switch engine	14,000.00
	Machine shop and equipment, tools, complete	11,438.42
	Electric welding outfits	2,460.00
	Foamite installation	48,790.00
	Local telephone system	3,500.00
12	Houses and bunk house and dining room	48,000.00
748	Piles and driving	11,168.00
	Concrete mixer with gasoline engine	1,300.00
	Team mules	600.00
	Wagon, plow, scrapers and mowing machine	1,280.00
2	Concrete tanks, 30′x60′x4′, for water	4,875.00
	Rope, blocks, shackles, shovels, picks, wheelbarrows, etc.	2,000.00
2	Trucks, one 5-ton and one 2-ton White	7,300.00
	Automobile—Ford	500.00
	Laboratory testing equipment	1,840.00
	Steam hoisting engine	4,000.00
	Roads, sidewalks, sewers, ditching, etc.	810.00
	Cement sidewalks	2,171.00
	Material and labor for equipment not shown	10,000.00
	Total	$1,047,142.88



STEEL SHELVING has become almost a necessity in industrial storeskeeping because of the multitude of parts, materials and supplies handled. Among the most important reasons for this are that it is non-combustible, conserves floor space and is easily converted into compartments suitable both to the commodity stored as well as the quantity handled. Other advantages and applications are discussed in this article.

With miscellaneous material it is often desirable to make compartments in a variety of sizes, as above. Valuable material may be locked in the cabinets.

Modern Practice
In the Use of

Shelves and Racks in Industrial Storerooms

For Storing Miscellaneous Repair and Maintenance Parts and Supplies as Well as Material both Before and After Manufacture and Between Operations During Work in Process

By FRANK E. GOODING
Associate Editor, Industrial Engineer

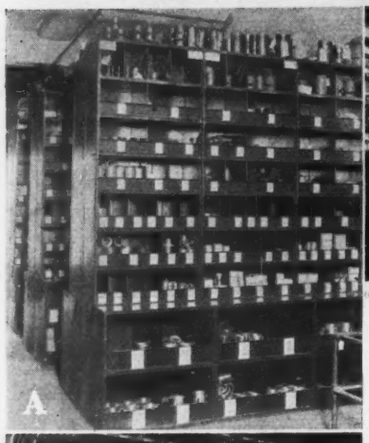
FACTORY housekeeping depends upon having adequate and proper storage space. It is impossible to go far in attempting to retain factory material, tools and supplies in orderly arrangement without storage facilities. For this purpose bins, open or closed types of shelves, and racks are most commonly used, not only because of the neat arrangement possible, but also because they multiply the amount of storage possible on a given floor space. Shelves from four to ten tiers high, provide storage space of approximately that many times the amount which could be stored on a similar floor area. This is a big advantage, as floor space is expensive. Also, when materials are stored together in good order they can be indexed, and located much more easily than if it were necessary to search around for them. Permanent storage spaces enable this to be done, whereas, if the material was promiscuously piled around on the floor, it would not be as easily nor as likely, to be indexed or located so specifically. Other advantages will be brought out later in this article.

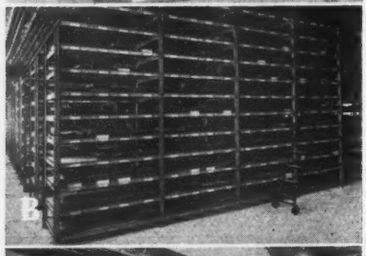
Wood and steel are the materials most commonly used for the construction of storage shelves. The objection that is raised against the use of wood is that it is combustible and will help feed any fire which may get started in the storeroom, even though the material stored is non-combustible. A fire will destroy or at least decrease the value of practically any line of material stored. Many manufactured parts when stored have a thin coating of oil which helps to retard rusting. This soaks off into the wood and makes it a still more dangerous fire hazard.

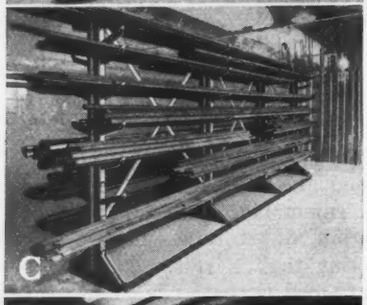
Also wood storage shelves cannot be made as strong in the joints. Neither can they be made, easily, in a form which can be knocked down for shipment, erected anywhere and then dismantled to be moved and erected again. Another objection is that after making wood up into bins or cabinets, it is practically impossible to enlarge the spaces without destroying or entirely rebuilding the bins. Other disadvantages may be easily seen from the contrast to the advantages of steel which will be given later. These, together with

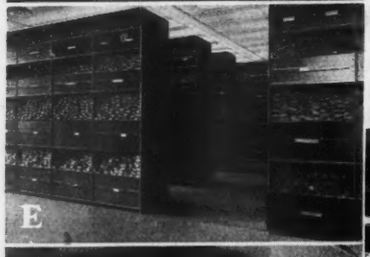
Some Typical Installations of Steel Shelving

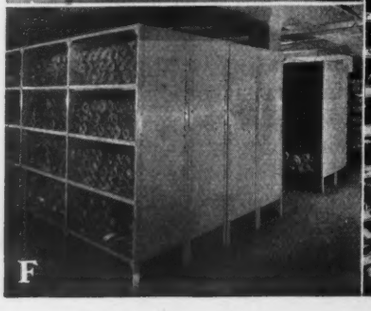
How This Equipment Is Used in Thirteen Plants

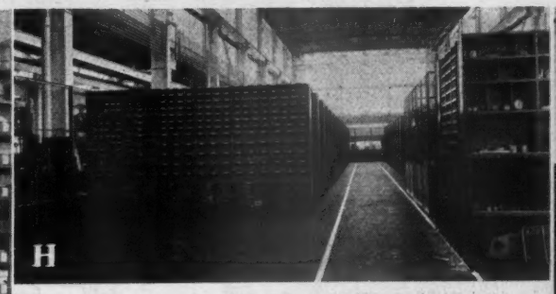












A—An example of ledge-style of closed shelving with bin front to carry cards indicating contents and divided into various sizes of compartments for handling miscellaneous material.

B—An example of open-type shelving for pattern storage with permanent movable ladder.

C—Pressed steel bar rack for storing pipe, shafting or steel bars. The arms are adjustable in height.

D—Open-type shelving supporting a heavy load of lithographing stones. The shelving is built around a locker installation in the far end of the room.

E—These closed shelves with large bin front support about 3,000 pounds of brass valves per shelf.

F—For storing extra long material two to four units of shelving are placed together without backs.

G—Closed shelving provided with drill inserts instead of shelves for use in a tool room. Each compartment has a hook for the brass check which shows who has received a tool.

H—A good example of a well-arranged store-room which is served by an overhead traveling crane. The first unit at the right shows how long materials may be stored.

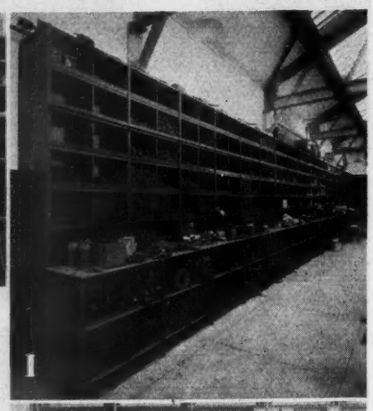
I—This shelving is made of 12-gage steel designed to carry a load of 500 lb. per sq. ft. The ledge, however, is meant to work on and not as a place to pile material.

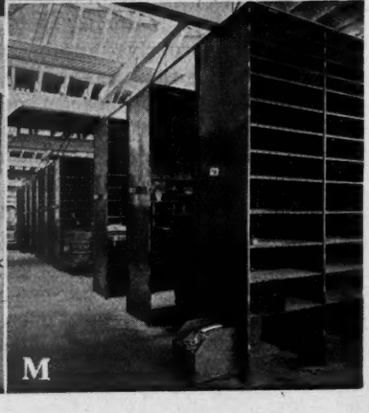
J—An example of convertible ledge style closed-type shelving with bin front in the lower sections and dividers making a variety of sizes of open compartments in the upper section.

K—An example of double-ledge shelving which gives considerably increased depth to the lower shelves.

L—This shows how neatly miscellaneous materials may be arranged on open or skeleton shelving.

M—Instead of subdividing the shelves into compartments, this concern has standardized on units 3 ft. wide, 3 ft. deep and 11 ft. high with steel boxes for storage of small articles. The shelves are spaced as required and have a ⅜-in. x 1-in. channel reinforcement front and back.





The space-saving advantages of steel over wood are well shown here.

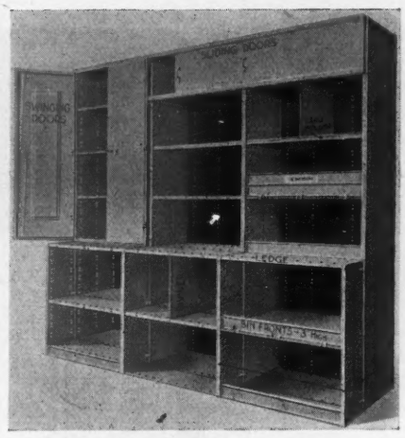
A gain of 20 per cent in storage capacity is made by using steel boxes instead of wood. Also the steel boxes are slightly deeper. The same advantage is obtained in the use of steel shelving instead of wood. In addition, steel shelving is noncombustible, does not loosen at the corners and will not wear from contact with sharp materials.

the additional fire hazard, have made wooden shelves and storage racks or bins less desirable. Still, they are often put in "temporarily" and all together too often are permitted to remain. Practically the only advantage of wooden equipment is that it can be home-made. This advantage is, however, often more than offset by its undesirable features. Also, even though such equipment is home-made this does not always mean that its cost is low.

Steel construction has so many advantages, however, that it is practically the only recommended material for bin or shelf construction. The first of these advantages is that steel is non-combustible. It does not soak up oil from machine parts in storage and so become combustible. Accumulations of dust or oil can be cleaned off at any time the bin is empty, if desired. Probably the next most important advantage of steel is in the ease with which it can be set up, added to or dismantled for re-assembly somewhere else.

Several types of standard shelvings are available, some of which are shown in the accompanying illustrations. In general these may be classified as closed types, when sides and backs are added and the shelves further subdivided into bins, and open-type shelving without sides or back. These are made to provide for several standard depths. The shelves near the floor are usually larger and are used to take care of the heavy materials or those which are in large quantities. Sometimes the bottom shelf rests on the floor or is left out so that the material rests directly on the floor. Usually it is better to set the bottom a few inches from the floor, particularly if on concrete floors which are to be cleaned by flushing with a hose. Under ordinary conditions a dust-proof setting may be made by keeping the bottom shelf off the floor a few inches and putting a bin front, which will be described later, under the front edge to close it off. In many cases, however, when this space underneath is left open it merely becomes a "catch-all."

One manufacturer makes closed-type shelving in the following standard dimensions: Standard unit heights of 4 ft., 5 ft., 6 ft., 7 ft., 8 ft. and 10 ft.; standard unit depths of 11¾ in., 14¾ in., 18 in., 24½ in. and 30½ in.; standard unit widths of 18 in., 24 in., 30 in. and 36 in. These may be used to make a variety of combinations, or units with as many shelves as desired inserted. The frame, back and side pieces are punched so as to permit of the shelves being spaced with a vertical adjustment of 2 in. or 3 in., depending on type. Each shelf is fastened to the two end pieces and also to the back. In addition, it is either



Make-up of three units of closed-type steel shelving.

The sections or units are separated by uprights extending from the floor to the top or distance *A*. The width of the unit is indicated by *C* and the depth by *E*. In this case a separate ledge, with a depth *D* and height *B*, is attached to the front, which increases the capacity of the lower compartments. The number of the compartments may be increased by adding dividers. Here the bottom plate rests on the floor. Sometimes it is omitted; in other cases it is raised 3 in. from the floor and a bin front inserted to close opening. Swinging and sliding doors, bin fronts and card holders may be used as shown. Frequently units are placed back-to-back, double-faced, to conserve space.

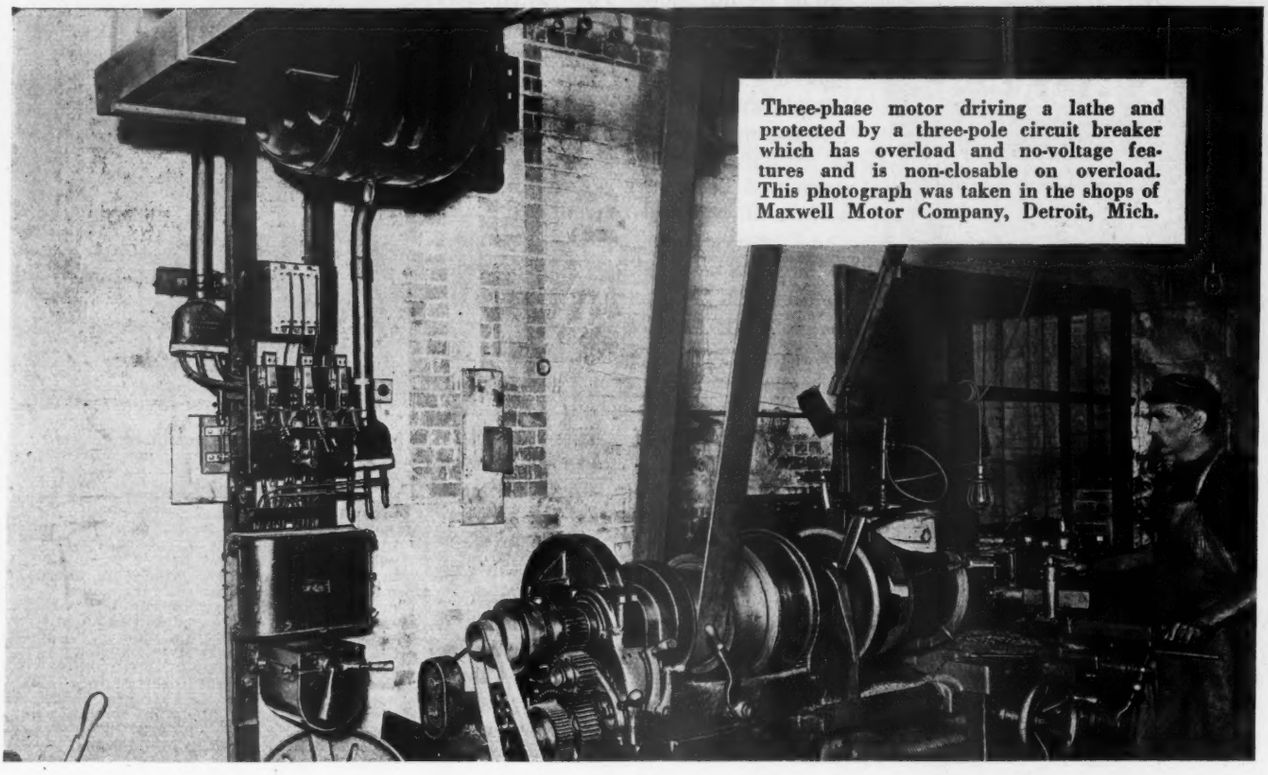
crimped or bent in such a way as to brace it along the front. For very heavy loads special bracing, angle-iron reinforcement in some cases, is inserted in the shelves to add strength.

The shelves may be further subdivided into sections or compartments by vertical dividers which are also spaced on 2- or 3-in. adjustments, the same as the vertical adjustment. These dividers are supplied in different heights in the same increment as the vertical adjustment spacing. To change the size of a compartment, it is only necessary to move a shelf up or down and increase or decrease the dividers both in height and in number to get an entire change in the shelving. This can usually be done without interfering with the remainder of the section.

When it is desired to make the lower shelves deeper a ledge may be added to the bin front. These are usually 3 ft. high and are made by one manufacturer in standard depths of 6 in., 9 in., 12 in. and 15 in. This gives (*Continued on page 602*)

A typical industrial installation of steel shelving.

All units in this installation are 3 ft. wide, 3 ft. deep and 11 ft. high with plete uprights. The shelves have a ⅜-in. by 1-in. channel reinforcement front and back. The lower shelf is left out and the space used for steel boxes on casters. The top of shelves should be 18 in. below sprinkler heads.



Three-phase motor driving a lathe and protected by a three-pole circuit breaker which has overload and no-voltage features and is non-closable on overload. This photograph was taken in the shops of Maxwell Motor Company, Detroit, Mich.

Points to Consider When Using

Circuit Breakers for Feeders and A. C. Motors

Together With Details of the Range of Protection That Can Be Provided Under Different Operating Conditions

By JAMES H. WYATT

Assistant Engineer, Cutter Electrical & Manufacturing Company, Philadelphia, Pa.

PROTECTION NEEDS for circuits and equipment are largely determined by the operating conditions met with in an industrial plant. When installing a circuit breaker for any purpose the range of operating conditions should be thoroughly understood. Among the things that must be considered are the nature of the load, the kind of motor used, the method of starting, the method of control and the class of operator. This article analyses the influence of each of these factors and then points out the suitability of various types of breakers to meet different conditions. Alternating-current service only is considered here, since a similar article on direct-current service was published in the November, 1923, issue of INDUSTRIAL ENGINEER.

PROTECTION of alternating-current motors by means of circuit breakers requires some features which are not necessary in protecting direct-current motors. The latter subject was treated in an article by the writer in the November, 1923, issue of INDUSTRIAL ENGINEER. The following article covers the same ground with regard to alternating-current motors. It also includes the protection of feeders for light or power service.

Single-phase, alternating-current motors may be protected in the same way as direct-current motors. It is true, however, that the starting currents of single-phase motors are usually higher than those of direct-current motors of the same rating, and this fact must be taken into consideration when choosing a circuit breaker.

In the use of circuit breakers for the protection of polyphase motors, due consideration must be given to the characteristics of the particular motor in question with special reference to the current required in starting as compared with that required by the normal load of the motor. This ratio will be found to vary considerably with different types of motors and different methods of starting. Oudin, in his book on "Standard Polyphase Apparatus and Systems," gives the data in Table I for some makes of motors with short-circuited armatures started at various percentages of the full-line voltage by means of auto-transformers or compensators employed to reduce the voltage at the terminals of the motor during the starting period.

From the data in Table I it will

be seen that when a motor of the short-circuited or squirrel-cage type of rotor is started by being thrown directly across the line, the starting current may be as much as seven times the full-load current. It is quite common practice to start motors of 5 hp. and less in this manner, but the method is obviously unsuitable where lights are operated from the circuits which supply the motors. It will at once be seen that where a motor of the type under discussion is started directly on the line, the maximum instantaneous current flow resulting therefrom cannot be exceeded by any other condition of load, either normal or otherwise. In view of this the ordinary form of overload circuit breaker is unsuitable for the protection of this class of motor. If adjusted to afford any protection whatever during running conditions, the circuit breaker will inevitably be opened by the heavy current incident upon starting. A circuit breaker for this kind of service must, therefore, permit the passage of the starting current for the necessary period, it must interrupt this starting current if unduly continued, and when the motor is running it should be responsive to sustained overloads above a predetermined value which may be considerably less in magnitude than the starting current. These conditions are well met by a circuit breaker having a time delay inversely proportional to the current.

With motors of 5 hp. and upwards it is customary to limit the current at starting by means of a compensator. This is an auto-transformer which gives a reduced voltage for starting. The starting of the motor is usually effected by a double-throw switch by means of which the motor is first connected into circuit through the auto-transformer and then thrown directly across the line. The coils of the starting device are usually provided with a number of taps so that the proportion of full voltage which will be applied to the motor with the switch in the starting position may be determined in accordance with the starting torque required. Where this is small, say one-third that corresponding with full load, the starting voltage need not be over 40 per cent of line voltage and the line starting current will exceed the full-load current by only about 12 per cent. The current flowing from the auto-starter to the motor will be greater than the line current in the proportion that its voltage is less, because the energy inflow and energy output of the auto-starter are practically equal quantities. The circuit breaker must, therefore, be connected, not between the motor and the auto-starter, but between the latter and the source of supply. If the motor is to be started with full-load torque then the starting voltage should be not less than 70 per cent of full-line voltage, and the line starting current will be approximately three and one-half times the full-load current, with correspondingly greater currents flowing from auto-starter to motor.

Table I—Starting Current and Torque of Squirrel-Cage Motors

Voltage In Per Cent of Rated Voltage	Line Starting Current In Per Cent of Full-load Current	Starting Torque In Per Cent of Full-load Torque
40	112	32
60	250	72
80	450	128
100	700	200

Inasmuch as auto-starters are intended only for intermittent service, they are proportioned accordingly and are not intended to be left in circuit for an undue length of time. The maximum current drawn from the line in starting a motor by means of an auto-starter is a function of the rating and design of the apparatus in question, and of the voltage which is supplied at the motor terminals, and is practically independent of the load on which the motor is started. It is true that if the motor is started on a light load the starting current will fall away more quickly than with a heavy load, but the initial or maximum value of this current will, in all cases, be practically the same for any given voltage, and where large starting torque is required the corresponding current will be much in excess of the continuous carrying capacity of the motor. Manufacturers of auto-starters realizing this condition have in some cases equipped their devices so that the

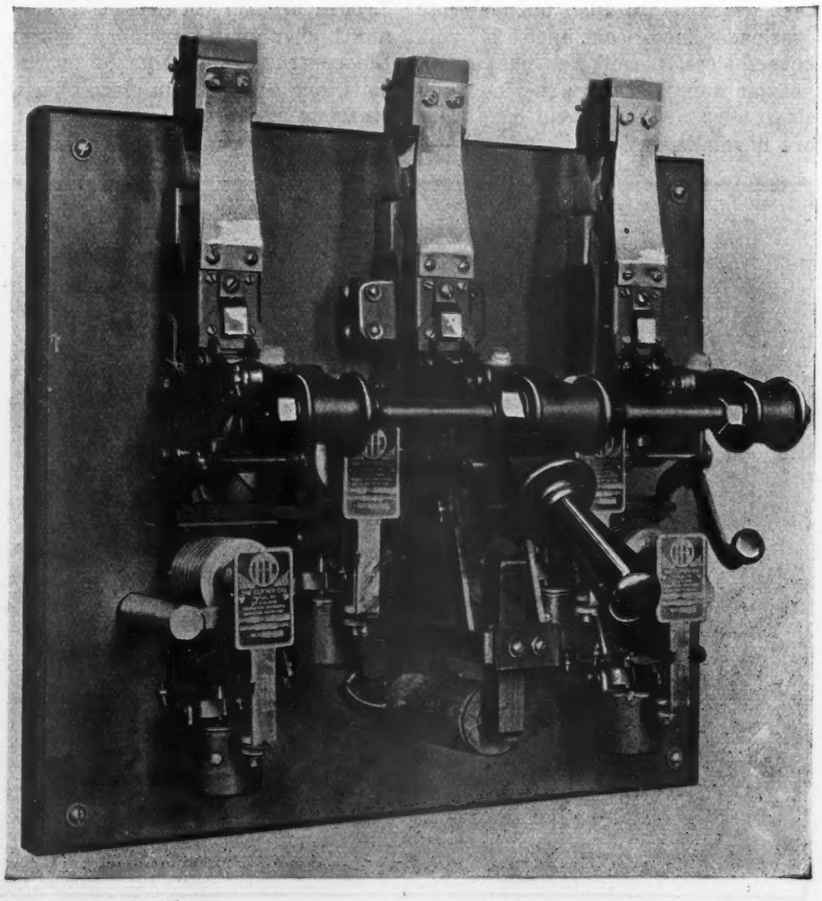


Fig. 1—A motor which is accelerated very gradually is protected by this breaker.

The breaker has two pairs of overload coils. One pair is connected in the starting leads of the compensator and the other pair in the line. The motor is slowly brought up to speed in several steps. If the controller is moved too fast the first pair of overload coils opens the breaker. This pair of coils has no time delay. The other pair which protects the motor under running conditions has inverse time delay.

circuit breaker may, if desired, be connected so that the overload features are effective only when the switch is in the running position.

The circuit breaker when so connected is, of course, not subject to the heavy starting current and the overload feature may, therefore, be set to operate at a current value determined only by running conditions. This method has on the other hand the disadvantage that it leaves the motor and the auto-starter without protection while the switch is in the starting position. The fact that the auto-starter is intended only for intermittent service suggests that this part of the equipment should be protected as well as the motor.

It is also obvious that the motor should be protected from undue continuance of heavy starting currents such as might result from attempts to start too heavily loaded, or with one phase disconnected. These combined requirements may be met in either of two ways. The first is by the employment of a time-limit circuit breaker so connected that the overload features will be in series with the motor both on starting and running. The characteristics of the time-limit circuit breaker are such that when set to open on moderate overloads long continued it will, nevertheless, permit the passage of heavier currents for a period sufficient for starting if load conditions are normal.

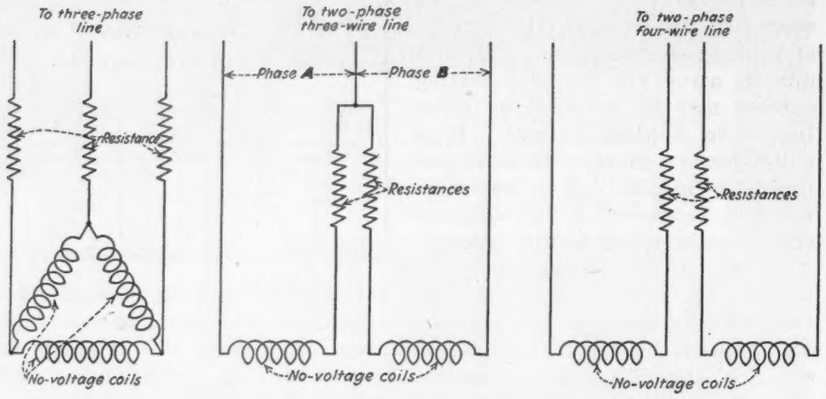


Fig. 3—Connections of no-voltage coils on polyphase circuits.
For a three-phase circuit breaker there must be three coils, while for a two-phase breaker two coils are required.

Obviously, with this arrangement the sensitiveness of the circuit breaker to overloads incident upon running is limited by the requirements of starting, and where motors are employed in connection with delicate mechanical operations it is sometimes desirable that the circuit breaker shall be responsive during running conditions to even the slightest overloads. To meet such contingencies a second method of protection may be used which involves the use of a special form of circuit breaker in which a single multi-polar switch member is under the control of two sets of overload coils, one set being in circuit on the starting side of the auto-starter, the other on the running side. In view of the fact already discussed, that the maximum instantaneous value of the starting current is practically independent of the load, it will at once be seen that the only protection possible during the starting period is not the limiting of the volume of this current, but the prevention of its undue continuance. Time limits are, therefore, essential adjuncts of the overload features connected on the starting side. They are also desirable on the running side unless the highest degree of sensitiveness to overload is required. Occasions sometimes arise, however, in which the character of the material handled or the nature of the operations performed is so delicate that the circuit breaker should operate instantly on the slightest increase in the load above a predetermined value. In this case the time-limit feature will not be required in conjunction with the running coils.

A modification of the foregoing case is presented where, in addition to the conditions already stated, the motor must be frequently stopped, and the starting must be accomplished gradually and with uniform acceleration in order to avoid injury to material in process. In such cases, where a motor of the squirrel-cage type is employed, the starting switch will be provided with a number of contacts, each connected with its respective taps from the auto-starter in such a way that the volt-

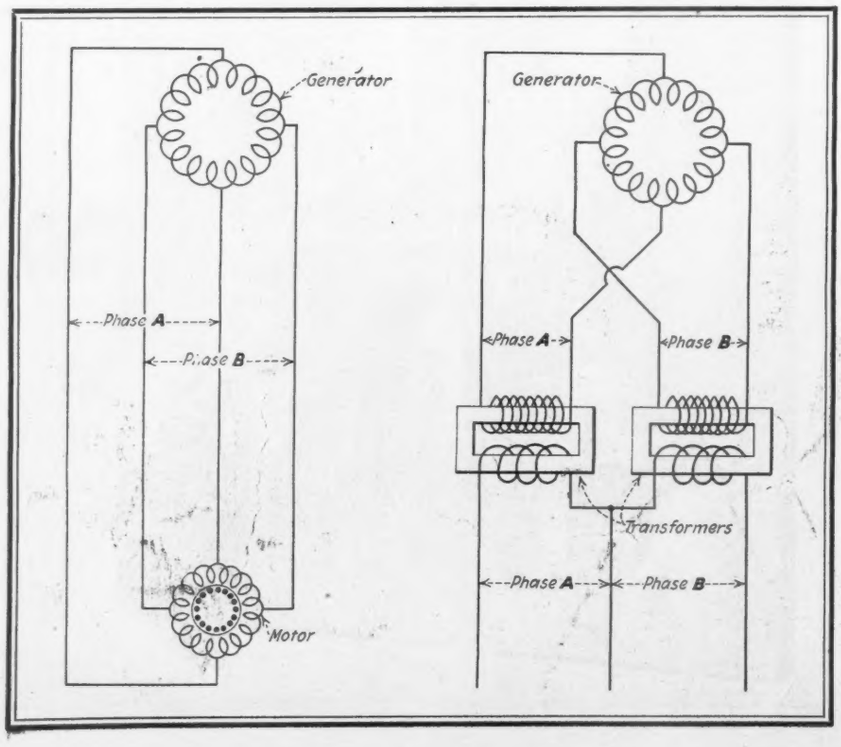


Fig. 2—Diagram showing when a three-pole breaker is necessary on a two-phase motor.
The drawing at the left illustrates a case where at least three poles are necessary in a circuit breaker. The phases of the two-phase motor are interconnected inside the motor while those of the generator are similarly interconnected. If only two poles were employed on the breaker voltage would still be impressed on the motor windings even after the breaker had opened. Two motors with interconnected phases and operating in parallel would likewise require three poles for each one. For three-wire, two-phase service as shown at the right a two-pole breaker usually suffices.

Table II—Starting Currents of Wound-Rotor Motors

These values are given by one manufacturer for 110-volt, three-phase, wound-rotor motors.

Horse-Power of Motor	Full Load Current, Amp.	Starting Current at 150 Per Cent of Full Load Torque, Amp.	Starting Current at Full Load Torque, Amp.
1	6.3	19	.....
2	12	36	.....
3	18	54	.....
5	28	*42-84	28
10	54	70	54
15	81	120	81
20	112	167	112
30	168	252	168
50	268	400	268
75	390	585	390
100	550	825	550
150	780	1180	780

*The 5-hp. motor is made with or without starting switch.

age applied to the motor is increased by a number of successive steps, and if the switch is properly handled the motor will come up to speed gradually and with an even acceleration. If, however, the starting switch is moved forward too rapidly, the current will become excessive, and the circuit should be instantly opened. Fig. 1 illustrates a three-pole circuit breaker which is especially adapted to this class of service.

Affording Protection for Motors with Wound Rotors

There are two sets of over-load coils, one set connected on the starting side and the other set on the line side. In this instrument the time-limit feature should be omitted from the starting coils because unlike the case immediately preceding, the volume of starting current which passes through them is variable and depends upon the manner in which the starting switch is handled. If the handle is moved forward too quickly the breaker will open and thus prevent damage to the work.

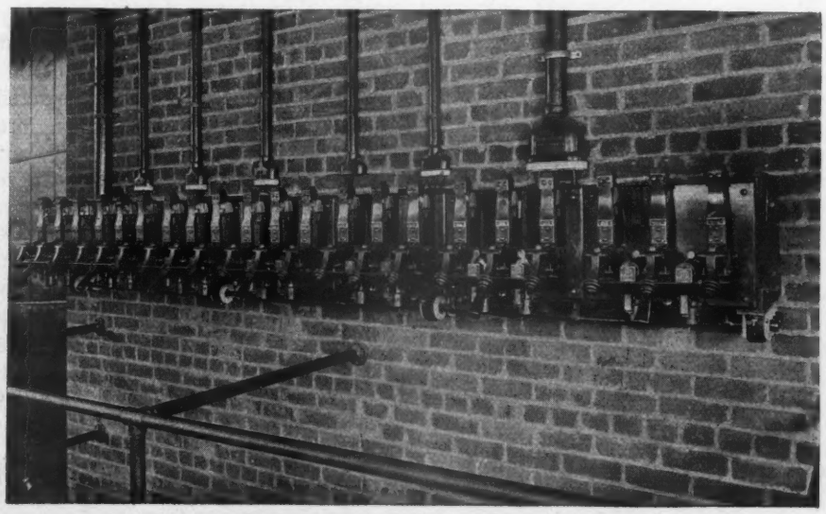
The foregoing discussion has dealt specifically with induction motors of the squirrel-cage type of armature and only casual reference has been made to the phase-wound type. This class of motor is characterized by a rotor having definite polar windings analogous to those of the primary. This form of motor is especially adapted for starting through resistance in the circuit of the rotor windings. The resistance is sometimes carried within the rotor and sometimes is external to it; in the latter case the rotor windings are connected with the starting switch through slip rings and brushes.

Usually for such a motor the circuit breaker which will give protection to the motor during running conditions will also protect it while it is being started. This is because the starting current is usually not greater than the full-load current. This is shown by Table II. This table relative to three-phase, 110-volt motors of the phase-wound type as supplied by a leading manufacturer, shows the relation between torque and starting current. While the figures given are for a specific voltage only, they show in a general way the ratios between the different quantities regardless of the operating voltage.

As may be seen from these figures, the current drawn on starting is directly proportional to the torque. With this type of motor the service performed by the machine driven by the motor will determine whether a time-limit feature is required or not.

Fig. 4—Three-pole circuit breakers on power feeders in the factory of the Hupp Motor Car Company.

These breakers protect three-phase feeder lines. They have an inverse-time overload feature. The individual motors supplied by lines branching from these, are protected by similar breakers.



How Many Poles Should the Circuit Breaker Have?

For three-phase, three-wire systems, three-pole circuit breakers are recommended as they afford means for completely disconnecting the motor from the system. Two-pole circuit breakers are, however, sometimes employed on the ground of economy. In either case, where the circuit breakers are of the overload type, there should not be less than two overload features in order that at least one of the two may be responsive to overload with any condition of circuit, balanced or unbalanced.

The conditions controlling the selection of circuit breakers for motors used on two-phase circuits demand fuller consideration. On two-phase, four-wire circuits, circuit breakers of at least three poles are required. This is because with circuit breakers of only two poles the motor may still be subjected to voltage if the motor has the two phases inter-connected in its windings, and in addition is supplied directly from a generator which has the two phases interconnected, or is operated in parallel with other motors which have the phases interconnected. This is illustrated in the left-hand drawing of Fig. 2. If a motor is operating under these conditions it will be subjected to a voltage of 0.7 times full voltage even though a two-pole circuit breaker has opened (one pole in each phase). The current to which a motor would be subjected under this condition would not sustain it in motion against a load and damage to the motor would probably result. Therefore, as the phases are often interconnected in the windings of two-phase motors, a circuit breaker of

Table III—Current per Kilowatt on Various A. C. Systems

This table shows the current per kilowatt at 100 per cent power factor. The values may also be used as approximate current per horsepower of induction-motor load assuming that the motors operate at about 86 per cent efficiency and 84 per cent power factor, which are reasonable values for motors over 5 hp., rated at least 860 r.p.m. and fully loaded.

Voltage	Amp. in Each Wire Per Kw. Load at 100 Per Cent Power Factor				
	Two-Wire Single-Phase	Four-Wire Two-Phase	Three-Wire Two-Phase		Three-Wire Three-Phase
			Outside Wires	Common Return	
110	9.1	4.5	4.5	6.43	5.25
220	4.55	2.27	2.27	3.21	2.62
330	3.03	1.51	1.51	2.14	1.75
440	2.27	1.13	1.13	1.60	1.31
550	1.82	.91	.91	1.29	1.05
1100	.91	.45	.45	.64	.53
2200	.46	.23	.23	.32	.26

at least three poles should be used. The fullest measure of protection will be secured by the use of four-pole breakers which, for reasons stated in the discussion relative to three-phase circuits, should be provided where protection against overloads is desired, with an overload coil in each of the two phases.

Sometimes where the two-phase system is supplied from transformers, a three-wire system of distribution is employed as shown in the right-hand side of Fig. 2. In this case the motor may be effectively protected from overload by the use of a two-pole instrument having two overload features. Unless the common main is grounded, however, a three-pole instrument is to be preferred, in which case the middle pole common to both phases should have a capacity 40 per cent in excess of that required for the outer poles, which each carry the current of one phase only.

All Poles Should Operate in Unison for Polyphase Circuits

Circuit breakers for the protection of all classes of polyphase motors should have the switch members rigidly united so that all poles will operate in unison both in opening and in closing. As the care of motor-driven machinery must often be placed in the hands of mechanics rather than trained electricians, it is highly important that the circuit breakers included in such equipments should be so designed that no possible method of handling them will defeat their protective operation. This requirement is admirably met by the circuit breaker which cannot be closed or held closed on overload. The construction of the breaker is such that when it operates on overload the switch arm is instantly released from the controlling lever, and the circuit is broken regardless of any pressure which may be exerted upon the handle. The usual hand switch may be omitted where this type of breaker is employed, as the instrument combines in itself the functions of both switch and circuit breaker.

The Breaker Should Open on Failure of Voltage

With the majority of polyphase motors a starting switch is employed in order to reduce the starting current, which would otherwise attain excessive magnitude. If the power supply should fail the motor should be automatically disconnected from the line. Should it remain in circuit it will be subjected to heavy currents when the line is again charged. This form of suddenly applied overload is likely to prove injurious to the motor, but especially so to the machinery which it drives.

Against such contingencies the motor can be properly protected by the use of a no-voltage attachment on the circuit breaker. The no-voltage device should be so constructed that it is automatically thrown into action by the closing of the breaker. The design should be such that there is no vibration of the armature. There should be a coil in each phase for polyphase motors, as shown in Fig. 3. This will result in a steady and strong magnetism for holding the armature. The stronger holding force allows the use of a strong spring for forcing the armature against the trigger when the armature is released.

The internal characteristics of many polyphase motors are such that after having been started from the polyphase circuit they will, if but lightly loaded, continue to run single-phase in the event of interruption of one main of the circuit, and when so running will sustain approximately normal voltage on the motor side of the disconnected main. Under such circumstances, therefore, the no-voltage feature will not respond. This condition is taken care of by the employment of circuit breakers combining both overload and no-voltage features.

Requirements of Protection for Power Feeders

A two-wire feeder circuit may be afforded protection during running conditions by the use of a single-pole circuit breaker which, if either main of the circuit be permanently grounded, must be installed in the ungrounded main. The term "running conditions" is used here in order to distinguish between the conditions which obtain while the feeder is actually supplying the power, and those which may exist at the moment the line is being connected into circuit at the switchboard. In the first mentioned instance, the circuit breaker is free to respond should the load become excessive, while in the second instance, if a single-pole circuit breaker of ordinary construction is made use of as the means of finally closing the feeder circuit, its ability to respond to such overload as may occur at the instant of closing is seriously impaired by the pressure exerted by the hand of the operator.

This has led to the practice of employing a hand switch in series with the circuit breaker, the method of operation being to open the hand switch before closing the circuit breaker, finally completing the circuit by closing the hand switch. Where this method is rigidly followed a single-pole circuit breaker may be relied upon to give protection not only under running conditions, but also while the feeder is being brought into circuit. Through haste or ignorance, however, it frequently happens that the operator will close the circuit breaker without first opening the hand switch. Such action is particularly likely after the circuit breaker has opened upon overload, and if attempted while the condition which gave rise to the overload still exists, damage is almost certain to result.

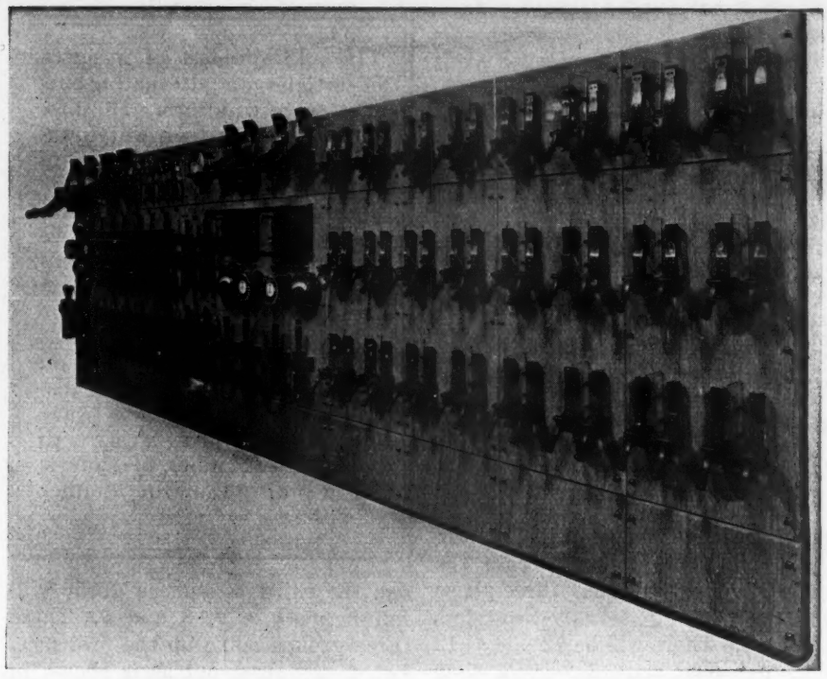


Fig. 5—Main and feeder circuit breakers on a switchboard.

The large breakers at the left of the board are on the main service panels. The breakers at the right control the feeder circuits.

These considerations make desirable the use of protective apparatus whose operation will be independent of the manner in which it is handled by the switchboard attendant, and have led to the development of two distinct types of circuit breakers, each of which admirably fulfills these conditions and renders the hand switch superfluous.

The first of these is the breaker with two members which are closed independently of each other. One member is closed and then the other. If there is a short circuit on the line the first member is free to open when the second is being closed.

The other type of circuit breaker which is suitable for a two-wire feeder is the one which is non-closable on overload. If an overload is present when the breaker is closed it will open at normal speed regardless of the pressure on the handle.

Conditions Determining Use of "Time-Limit" on Feeders

Circuit breaker equipment should be chosen so as to give the full measure of protection without occasioning unnecessary interruption in the service. Short-circuit currents such as may result from accidental crosses or from defects in insulation reach a magnitude not generally appreciated, and the same may also be said of currents frequently arising through improper handling of apparatus, or as the result of defects in the apparatus itself. While such currents, especially when superimposed upon normal load currents of considerable volume, are likely to exceed the capacity of the feeders, it is not always desirable that the feeder circuit breakers should open and thus disconnect other branch circuits in which the conditions are normal. To meet such contingencies, therefore, it is recommended that both light and power feeders be protected with time-limit circuit breakers, and that the various sub-divisions of the circuit be also protected by circuit breakers of smaller capacity installed at the centers of distribution. In the case of motors, each should be protected by its individual circuit breaker. Where this method is followed, only the portion of the circuit in which the trouble arises will be disconnected and the feeder breakers will operate only in the event of sustained overloads.

Factors in Protection of Three-Wire Feeders

The points just covered as to the use of time-limit circuit breakers and the protection of branch circuits, apply to three-wire circuits with the same force as they do to two-wire circuits. On three-wire lighting feeders in order to avoid excess voltage on lamps as the result of unbalanced load, it is essential that the neutral main shall not be opened unless at least one of the mains is already open or is opened at the same time. It is also desirable that the two main leads of the circuit shall be opened or closed together, as otherwise the neutral and compensators might be unduly loaded.

With these facts in view it will be seen that the circuit breaker should have at least two poles, that these should be connected into the two main leads and that they should be rigidly united in order to secure their simultaneous action both in opening and closing. As the load in each of these two leads is not necessarily the same, each of the two poles should be provided with an overload coil, and the breaker should be non-closable on a definite overload.

Use of this instrument meets the protective requirements of the average lighting feeder on which the conditions of service are such that extensive unbalancing of the load is improbable. However, on lighting feeders in which serious unbalancing is likely to occur, likewise on power feeders, the circuit breaker should be provided with a third overload feature for connection into the neutral main. The object of the third overload device is to limit the neutral current to the safe carrying capacity of the compensating devices. This class of instrument, more particularly when equipped with time-limit features, meets every requirement of three-wire feeder protection. The use of the third or neutral overload feature is especially desirable where the unbalanced load is taken care of by a compensator whose capacity is small in comparison with that of the main generators. Where it is not desired to interrupt the neutral main, the center switch member may be omitted, the corresponding overload feature being retained, as it is highly important that the compensator be kept in service. To this end the unbalanced load must be prevented from attaining excessive values in any of the various sections of the circuit in which they may arise.

There still remains the possibility of the cumulative effect of the unbalanced current in several feeders being sufficient to overtax the capacity of the compensator. Whether or not this danger is sufficient to warrant the installation of protective devices directly in the circuit of the compensator, is a matter to be decided in accordance with the service

conditions. (Continued on page 601)

Handy Tables For Use in

Laying Out Wave Windings for A.C. Rotors

Having 120-deg. Spacing Between Line Leads Together With Instructions for Calculating Wave Windings for Machines in Which the Number of Slots Is Not a Multiple of the Number of Poles

THIS IS the last of a series of articles on alternating-current, wave windings. The first three articles, which were published in the September, October, and November issues, explained how to lay out and construct stator wave windings and also gave short-cut methods and tabulations of data for use in laying out this type of winding. This article gives similar tabulations for use on rotor windings and also discusses how to lay out wave windings for machines in which the number of slots is not a multiple of the number of poles.

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PREVIOUS articles in the September, October and November issues explained how to lay out and construct wave windings for alternating-current motors. Tables and short-cut methods have also been given which will greatly shorten the time and effort in accomplishing this work. We will now discuss wave windings having a spacing of 120 deg. between the line leads.

Tables I to V give the data for three-phase rotor or stator windings having a spacing of 120 deg. between the line leads. This type of connection is used principally on rotors; consequently, only the three-phase star and delta connecting data are given.

These tables are worked up in a manner similar to those that have been described in the November issue. The only difference is in locating the leads, for these tables give the winding data for windings having 120-deg. lead spacing instead of having the line leads placed as close together as possible. The starting lead of the A phase will of course be located in slot *1* and the starting lead of the B and C phases will be spaced 120 deg. each way from the starting lead of the A phase. For example, in a ninety-six-slot machine, the leads would be spaced $96 \div 3 = 32$ slots apart. Then if the A phase starts in slot *1*, the B phase would start in $1 + 32 =$ slot *33*, and the C phase would start in $33 + 32 =$ slot *65*.

Dividing the total number of slots by 3, to obtain the 120-deg. spacing will not hold true of windings for six, twelve, eighteen, twenty-four, etc., poles. To show the method of locating the 120-deg. spacing for these windings, we will locate the leads for a six-pole, three-phase winding having seventy-two slots and coils. There will be $72 \div 6 = 12$ slots per pole and $12 \div 3 = 4$ slots per pole per phase. We will start the A_1 lead in slot *1* and since the winding is retrogressive, the three remaining slots of that pole-phase group will fall in slots *72, 71* and *70*. This is the first pole-phase group of the first pole. The second pole-phase group will fall in slots *2, 3, 4* and *5* and the third pole-phase group will fall in slots *6, 7, 8* and *9*. These three groups make up the first pole. Let us lay them out as is shown in Fig. 1. We will indicate the polarity of this pole by the arrow pointing up. The other poles are laid out in a similar manner as is shown in Fig. 1. Adjacent poles are of opposite polarity as is indicated by the arrows placed at the end of each pole group.

Fig. 1—Method of locating slots for starting leads of each phase for windings of six, twelve, eighteen, etc., poles when 120-deg. lead spacing is desired.

The A phase is started in slot *1*, thereby reserving the left-hand pole-phase group in each pole for the A phase. For exactly 120-deg. spacing, the B phase would start in slot *25*. This slot is in an A pole-phase group, so slot *29* is selected for the B-phase starting lead. To have exactly 120-deg. spacing the C phase would start in slot *49*. This slot is in a pole-phase group reserved for the A phase and has the same polarity (indicated by arrows at right) as the poles in which the other starting leads are located. Hence, the starting lead for the C phase is located in slot *45* which has the correct polarity and is in a pole-phase group that is not used by the A or B phases.

To have exactly 120-deg. spacing between the leads, there would be $72 \div 3 = 24$ slots between each pair of leads; that is, the leads would fall in slots *1, 25* and *49*. As was said before, we will start the A_1 lead in slot *1* as is marked in the first pole-phase group in Fig. 1. This reserves the first pole-phase group of the first pole and of the succeeding poles for the A phase. For 120-deg. spacing, the B-phase starting lead should fall in slot *25*. Slot *25* falls in the first pole-phase group of the third pole. This pole-phase group was reserved for the A phase, when we placed the

First Pole	(70, 71, 72, *1) A_1	(2, 3, 4, 5)	(6, 7, 8, 9)	↑
Second Pole	(10, 11, 12, 13)	(14, 15, 16, 17)	(18, 19, 20, 21)	↓
Third Pole	(22, 23, 24, *25)	(26, 27, 28, 29) B_1	(30, 31, 32, 33)	↑
Fourth Pole	(34, 35, 36, 37)	(38, 39, 40, 41)	(42, 43, 44, 45) C_1	↓
Fifth Pole	(46, 47, 48, *49)	(50, 51, 52, 53)	(54, 55, 56, 57)	↑
Sixth Pole	(58, 59, 60, 61)	(62, 63, 64, 65)	(66, 67, 68, 69)	↓

Winding to have 6 poles, 72 slots
* = Location of slots having 120-degree spacing
Arrows indicate polarity of poles

starting lead of the A phase in slot *1*; consequently, slot *25* cannot be used for the B_1 lead. However, slot *29* is available and falls in the second pole-phase group; therefore, we will use slot *29* in which to start the B_1 lead. We have said before that the instantaneous polarity of two phases must be the same while the third one is opposite. The A and B phases are to have the same instantaneous polarity. The first and third poles have the same instantaneous polarity; therefore, slot *29* will be suitable for the B phase from this point of view.

For 120-deg. spacing, the starting lead of the C phase would fall in slot *49*. Slot *49* falls in an A-phase, pole-phase group as is shown in fifth pole of Fig. 2, and has the same polarity as the other poles in which the two other phases were started. Therefore, slot *49* cannot be used to start the B_1 lead. However, slot *45* falls in a pole of the opposite polarity and also falls in a pole-phase group that is not reserved for either the A or B phases. We will start the C_1 lead in slot *45*.

Table I—Four-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads

These tables give the arrangement for a series-star connection. To obtain a series-delta connection, connect A and C_1 to one line, B and A_1 to the second line and C and B_1 to the third line.
For a left-hand winding number slots in a clockwise direction.
For a right-hand winding number slots in a counter-clockwise direction.
"Top" refers to top conductor in slot; "bottom" refers to bottom conductor in slot.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
24	4	2	1 & 7	1	9	17	19	3	11	(12- 18) (20-2) (4-10)	(19-24) (13-18) (3-8) (21-2) (11-16) (5-10)
36	6	3	1 & 10	1	13	25	28	4	16	(17- 26) (29-2) (5-14)	(27- 35, 28- 36) (18- 26, 19- 27) (3-11, 4-12) (30-2. 31- 3) (15- 23, 16- 24) (6-14, 7-15)
48	8	4	1 & 13	1	17	33	37	5	21	(22- 34) (38-2) (6-18)	(35- 46, 37- 48) (23- 34, 25- 36) (3-14, 5-16) (39-2, 41- 4) (19- 30, 21- 32) (7-18, 9-20)
60	10	5	1 & 16	1	21	41	46	6	26	(27- 42) (47-2) (7-22)	(43- 57, 46- 60) (28- 42, 31- 45) (3-17, 6-20) (48-2, 51- 5) (23- 37, 26- 40) (8-22, 11-25)
72	12	6	1 & 19	1	25	49	55	7	31	(32- 50) (56-2) (8-26)	(51- 68, 55- 72) (33- 50, 37- 54) (3-20, 7-24) (57-2, 61- 6) (27- 44, 31- 48) (9-26, 13-30)
84	14	7	1 & 22	1	29	57	64	8	36	(37- 58) (65-2) (9-30)	(59- 79, 64- 84) (38- 58, 43- 63) (3-23, 8-28) (66-2, 71- 7) (31- 51, 36- 56) (10-30, 15-35)
96	16	8	1 & 25	1	33	65	73	9	41	(42- 66) (74-2) (10-34)	(67- 90, 73- 96) (43- 66, 49- 72) (3-26, 9-32) (75-2, 81- 8) (35- 58, 41- 64) (11-34, 17-40)
108	18	9	1 & 28	1	37	73	82	10	46	(47- 74) (83-2) (11-38)	(75-101, 82-108) (48- 74, 55- 81) (3-29, 10-36) (84-2, 91- 9) (39- 65, 46- 72) (12-38, 19-45)
120	20	10	1 & 31	1	41	81	91	11	51	(52- 82) (92-2) (12-42)	(83-112, 91-120) (53- 82, 61- 90) (3-32, 11-40) (93-2, 101-10) (43- 72 51- 80) (13-42, 21-50)
132	22	11	1 & 34	1	45	89	100	12	56	(57- 90) (101-2) (13-46)	(91-123, 100-132) (58- 90, 67- 99) (3-35, 12-44) (102-2, 111-11) (47- 79, 56- 88) (14-46, 23-55)
144	24	12	1 & 37	1	49	97	109	13	61	(62- 98) (110-2) (14-50)	(99-134, 109-144) (63- 98, 73-108) (3-38, 13-48) (111-2, 121-12) (51- 86 61- 96) (15-50, 25-60)
156	26	13	1 & 40	1	53	105	118	14	66	(67-106) (119-2) (15-54)	(107-145, 118-156) (68-106, 79-117) (3-41, 14-52) (120-2. 131-13) (55- 93, 66-104) (16-54, 27-65)
168	28	14	1 & 43	1	57	123	127	15	71	(72-114) (128-2) (16-58)	(115-156, 127-168) (73-114, 85-126) (3-44, 15-56) (129-2, 141-14) (59-100, 71-112) (17-58, 29-70)
180	30	15	1 & 46	1	61	131	136	16	76	(77-122) (137-2) (17-62)	(123-167, 136-180) (78-122, 91-135) (3-47, 16-60) (138-2, 151-15) (63-107, 76-120) (18-62, 31-75)
192	32	16	1 & 49	1	65	139	145	17	81	(82-130) (146-2) (18-66)	(131-178, 145-192) (83-130, 97-144) (3-50, 17-64) (147-2, 161-16) (67-114, 81-128) (19-66, 33-80)
204	34	17	1 & 52	1	69	147	154	18	86	(87-138) (155-2) (19-70)	(139-189, 154-204) (88-138, 103-153) (3-53, 18-68) (156-2. 171-17) (71-121, 86-136) (20-70, 35-85)
216	36	18	1 & 55	1	73	155	163	19	91	(92-146) (164-2) (20-74)	(147-200, 163-216) (93-146, 109-162) (3-56, 19-72) (165-2, 181-18) (75-128, 91-144) (21-74, 37-90)

Table II—Six-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
36	6	2	1 & 7	1	15	23	31	9	17	(24- 30) (2- 8) (10-16)	(31-36) (25-30) (9-14) (3-8) (17-22) (11-16)
54	9	3	1 & 10	1	22	34	46	13	25	(35- 44) (2-11) (14-23)	(45- 53, 46- 54) (36- 44, 37- 45) (12-20, 13-21) (3-11, 4-12) (24- 32, 25- 33) (15-23, 16-24)
72	12	4	1 & 13	1	29	45	61	17	33	(46- 58) (2-14) (18-30)	(59- 70, 61- 72) (47- 58, 49- 60) (15-26, 17-28) (3-14, 5-16) (31- 42, 33- 44) (19-30, 21-32)
90	15	5	1 & 16	1	36	56	76	21	41	(57- 72) (2-17) (22-37)	(73- 87, 76- 90) (58- 72, 61- 75) (18-32, 21-35) (3-17, 6-20) (38- 52, 41- 55) (23-37, 26-40)
108	18	6	1 & 19	1	43	67	91	25	49	(68- 86) (2-20) (26-44)	(87-104, 91-108) (69- 86 73- 90) (21-38, 25-42) (3-20, 7-24) (45- 62 49- 66) (27-44, 31-48)
126	21	7	1 & 22	1	50	78	106	29	57	(79-100) (2-23) (30-51)	(101-121, 106-126) (80-100, 85-105) (24-44, 29-49) (3-23, 8-28) (52- 72, 57- 77) (31-51, 36-56)
144	24	8	1 & 25	1	57	89	121	33	65	(90-114) (2-26) (34-58)	(115-138, 121-144) (91-114, 97-120) (27-50, 33-56) (3-26 9-32) (59- 82, 65- 88) (35-58, 41-64)
162	27	9	1 & 28	1	64	100	136	37	73	(101-128) (2-29) (38-65)	(129-155, 136-162) (102-128, 109-135) (30-56, 37-63) (3-29, 10-36) (66- 92, 73- 99) (39-65, 46-72)
180	30	10	1 & 31	1	71	111	151	41	81	(112-142) (2-32) (42-72)	(143-172, 151-180) (123-142, 121-150) (33-62, 41-70) (3-32, 11-40) (73-102, 81-110) (43-72, 51-80)
198	33	11	1 & 34	1	78	122	166	45	89	(123-156) (2-35) (46-79)	(157-189, 166-198) (134-156, 133-165) (36-68. 45-77) (3-35, 12-44) (80-112, 89-121) (47-79, 56-88)
216	36	12	1 & 37	1	85	133	181	49	97	(134-170) (2-38) (50-86)	(171-206, 181-216) (145-170, 145-180) (39-74. 49-84) (3-38. 13-48) (87-122, 97-132) (51-86, 61-96)

Table III—Eight-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A_1	Star Top B_1	Star Top C_1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
24	4	1	1 & 4	1	17	9	22	14	6	(19- 22)(11- 14)(3- 6)	None
48	8	2	1 & 7	1	33	17	43	27	11	(36- 42)(20- 26)(4-10)	(43-48) (37-42) (27-32) (21-26) (11-16) (5-10)
72	12	3	1 & 10	1	49	25	64	40	16	(53- 62)(29- 38)(5-14)	(63- 71, 64- 72)(54- 62, 55- 63)(39- 47, 40- 48)(30- 38, 31- 39)(15-23, 16-24)(6-14, 7-15)
96	16	4	1 & 13	1	65	33	85	53	21	(70- 82)(38- 50)(6-18)	(83- 94, 85- 96)(71- 82, 73- 84)(51- 62, 53- 64)(39- 50, 41- 52)(19-30, 21-32)(7-18, 9-20)
120	20	5	1 & 16	1	81	41	106	66	26	(87-102)(47- 62)(7-22)	(103-117, 106-120)(88-102, 91-105)(63- 77, 66- 80)(48- 62, 51- 65)(23-37, 26-40)(8-22, 11-25)
144	24	6	1 & 19	1	97	49	127	79	31	(104-122)(56- 74)(8-26)	(123-140, 127-144)(105-122, 109-126)(75- 92, 79- 96)(57- 74, 61- 78)(27-44, 31-48)(9-26, 13-30)
168	28	7	1 & 22	1	113	57	148	92	36	(121-142)(65- 86)(9-30)	(143-163, 148-168)(122-142, 127-147)(87-107. 92-112)(66- 86, 71- 91)(31-51, 36-56)(10-30, 15-35)
192	32	8	1 & 25	1	129	65	169	105	41	(138-162)(74- 98)(10-34)	(163-186, 169-192)(139-162, 145-168)(99-122, 105-128)(75- 98, 81-104)(35-58, 41-64)(11-34, 17-40)
216	36	9	1 & 28	1	145	73	190	118	46	(155-182)(83-110)(11-38)	(183-209, 190-216)(156-182, 163-189)(111-137, 118-144)(84-110, 91-117)(39-65,(46-72)(12-38, 19-45)
240	40	10	1 & 31	1	161	81	211	131	51	(172-202)(92-122)(12-42)	(203-232, 211-240)(173-202, 181-210)(123-152, 131-160)(93-122, 101-130)(43-72, 51-80)(13-42, 21-50)

So far we have discussed wave windings that have an equal number of coils in each section. Some wave windings will be found that have an equal number of coils in each phase but an unequal number of coils in each section. For example, consider an eighty-four-slot stator wound with a two-layer, left-hand, retrogressive, wave winding having eight poles and eighty-four coils connected series star. In this winding, there will be $84 \div 3 = 28$ coils per phase. Since the number of sections is equal to twice the number of phases, the number of coils per section will equal $84 \div 6 = 14$ coils per section. In a wave winding, the coils per section must be a multiple of the number of pairs of poles; that is, a section must start and finish in a pole-phase group belonging to the same phase and located in an adjacent pole. In this case the number of coils per section is not a multiple of the pairs of poles, for the coils per section equal $84 \div 6 = 14$, and the pairs of poles equal $8 \div 2 = 4$ and $14 \div 4 = 3\frac{1}{2}$. A section with this layout would encircle the stator three and one-half times and would not finish in a pole-phase group of an adjacent pole and which corresponded with the pole-phase group of the starting lead.

To lay out a winding for this combination of poles and slots, first divide the winding so that there will be an equal number of coils per phase; that is, $84 \div 3 = 28$ coils per phase. Then divide the coils per phase by the number of pairs of poles, in this case $28 \div 4 = 7$, which means that to pick up the twenty-eight coils in one phase, the winding must be encircled seven times. Since each phase is divided into two sections, we will divide the encircling number by two; that is, $7 \div 2 = 3$ with a remainder of 1, or $4+3=7$. Therefore, to pick up twenty-eight coils per phase and at the same time to encircle the winding seven times in doing so, one section of the phase must contain $3 \times 4 = 12$ coils and the other section must contain $4 \times 4 = 16$ coils.

The winding pitch equals the total number of slots divided by half the number of poles equals $84 \div 4 = 21$, or a pitch of 1-and-22. Hence, the front and back pitches will be unequal as $21 \div 2 = 10\frac{1}{2}$. Make the back pitch equal to 11, or a pitch of 1-and-12 and the front pitch equal to 10, or a pitch of 1-and-11. Using the front and back pitch as calculated, lay out the first section of sixteen coils in the manner shown at *M* of Fig. 2. Likewise, lay out the second section of this phase as is shown at *N* in Fig. 2.

The next step is to check the phase-belt overlapping. With this type of winding, there will be a number of slots in which the top and bottom coil halves will belong to different phases. It will be necessary to locate these slots and also to determine to which phases the various coil sides belong. Let us start with the first slot number in the first section of the A phase. This is shown at *M* of Fig. 2. As determined before, we have found that the winding is encircled seven times to pick up all the coils of one phase. We also decided that the winding was to be encircled four times to pick up the coils of the first section and encircled three times to pick up the coils of the second section; that is, $4 + 3 = 7$, which is the total number of times the winding is encircled to pick up all the coils of one phase. Now, since the winding is retrogressive and is encircled four times in picking up the coils of the first section, a pole-phase group will contain four slots and these slots will be *1*, *84*, *83* and *82*. The A phase starts in slot *1*; that is the reason that we have picked out slot *1* and the winding being retrogressive, it would naturally follow that slots *84*, *83* and *82* would be the other slots of that pole-phase group. We will now lay out the slots in order as is shown at the bottom of Fig. 2, beginning with slot *82* and following consecutively through all the slots of the machine. Now, check through the first section as shown at *M* of Fig. 2 to see whether slots *1*

Table IV—Ten-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A1	Star Top B1	Star Top C1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
30	5	1	1 & 4	1	11	21	28	8	18	(25- 28)(5- 8)(15- 18)	None
60	10	2	1 & 7	1	21	41	55	15	35	(48- 54)(8-14)(28- 34)	(55-60) (49-54) (15-20) (9-14) (35-40) (29-34)
90	15	3	1 & 10	1	31	61	82	22	52	(71- 80)(11-20)(41- 50)	(81- 89, 82- 90)(72- 80, 73- 81)(21-29, 22-30)(12-20, 13-21)(51- 59, 52- 60)(42- 50, 43- 51)
120	20	4	1 & 13	1	41	81	109	29	69	(94-106)(14-26)(54- 66)	(107-118, 109-120)(95-106, 97-108)(27-38, 29-40)(15-26, 17-28)(67- 78, 69- 80)(55- 66, 57- 68)
150	25	5	1 & 16	1	51	101	136	36	86	(117-132)(17-32)(67- 82)	(133-147, 136-150)(118-132, 121-135)(33-47, 36-50)(18-32, 21-35)(83- 97, 86-100)(68- 82, 71- 85)
180	30	6	1 & 19	1	61	121	163	43	103	(140-158)(20-38)(80- 98)	(159-176, 163-180)(141-158, 145-162)(39-56, 43-60)(21-38, 25-42)(99-116, 103-120)(81- 98, 85-102)
210	35	7	1 & 22	1	71	141	190	50	120	(163-184)(23-44)(93-114)	(185-205, 190-210)(164-184, 169-189)(45-65, 50-70)(24-44, 29-49)(215-135, 120-140)(94-114, 99-119)
240	40	8	1 & 25	1	81	161	217	57	137	(186-210)(26-50)(106-130)	(211-234, 217-240)(187-210, 193-216)(51-74, 57-80)(27-50, 33-56)(231-154, 137-160)(107-130, 113-136)

Table V—Twelve-Pole, Three-Phase Windings

Having 120-Deg. Spacing Between Line Leads
See heading of Table I for instructions on using table.

No. of Coils	Coils Per Section	Coils Per Group	Pitch	Leads Top A	Leads Top B	Leads Top C	Star Top A1	Star Top B1	Star Top C1	Reversing Jumpers Bottom to Bottom	Short-Pitch Connections Connect Bottom to Top
36	6	1	1 & 4	1	14	30	34	11	27	(31- 34)(8-11)(24- 27)	None
72	12	2	1 & 7	1	27	59	67	21	53	(60- 66)(14-20)(46- 52)	(67-72) (61-66) (21-26) (15-20) (53-58) (47-52)
108	18	3	1 & 10	1	40	88	100	31	79	(89- 98)(20-29)(68- 77)	(99-107, 100-108)(90- 98, 91- 99)(30-38, 31-39)(21-29, 22-30)(78- 86, 79- 87)(69- 77, 70- 78)
144	24	4	1 & 13	1	53	117	133	41	105	(118-130)(26-38)(90-102)	(131-142, 133-144)(119-130, 121-132)(39-50, 41-52)(27-38, 29-40)(103-114, 105-116)(91-102, 93-104)
180	30	5	1 & 16	1	66	146	166	51	131	(147-162)(32-47)(112-127)	(163-177, 166-180)(148-162, 151-165)(48-62, 51-65)(33-47, 36-50)(128-142, 131-145)(113-127, 116-130)
216	36	6	1 & 19	1	79	175	199	61	157	(176-194)(38-56)(134-152)	(195-212, 199-216)(177-194, 181-198)(57-74, 61-78)(39-56, 43-60)(153-170, 157-174)(135-152, 139-156)
252	42	7	1 & 22	1	92	204	132	71	183	(205-226)(44-65)(156-177)	(227-247, 232-252)(206-222, 211-231)(66-86, 71-91)(45-65, 50-70)(178-198, 183-203)(157-187, 162-182)

84, *83* and *82* are occupied by any of the first section coils. In the coils shown at *M* of Fig. 2, the left-hand coil side falls in the top of the slot and the right-hand coil side falls in the bottom of the slot. In checking through the first section shown at *M* of Fig. 2, we find that the top conductors in slots *1*, *84*, *83* and *82* are used by this section. In checking through the second section, we find that the second section uses the bottom conductors in slots *1*, *84* and *83*, and that the bottom conductor in slot *82* is left open to be used by some other phase. We will draw a horizontal line above those slots in which both conductors are used by the same phase as is shown at *A* in the diagram at the bottom of Fig. 2. The A phase uses only the top conductor in slot *82*; therefore, we will draw a diagonal line in the direction shown to indicate this fact. If a bottom coil had been used in this slot by this phase, the diagonal line would have been drawn at right angles to this one.

We will now treat the second slot number of the first section in a similar manner. The second slot number of the first section is slot *12*. The other three slots of this pole-phase group are *11*, *10* and *9*. Checking through the first and second sections of the A phase as shown at *M* and at *N* of Fig. 2, we find that the first section uses the bottom conductors in all four slots and that the second section uses the top conductor in slots *9*, *10* and *11*. We mark a horizontal line above slots *9*, *10* and *11* and a diagonal line through slot *12* in the small diagram shown at the bottom of Fig. 2. Check the remaining slots of the first series of coils in the same manner. This will locate all of the A pole-phase groups.

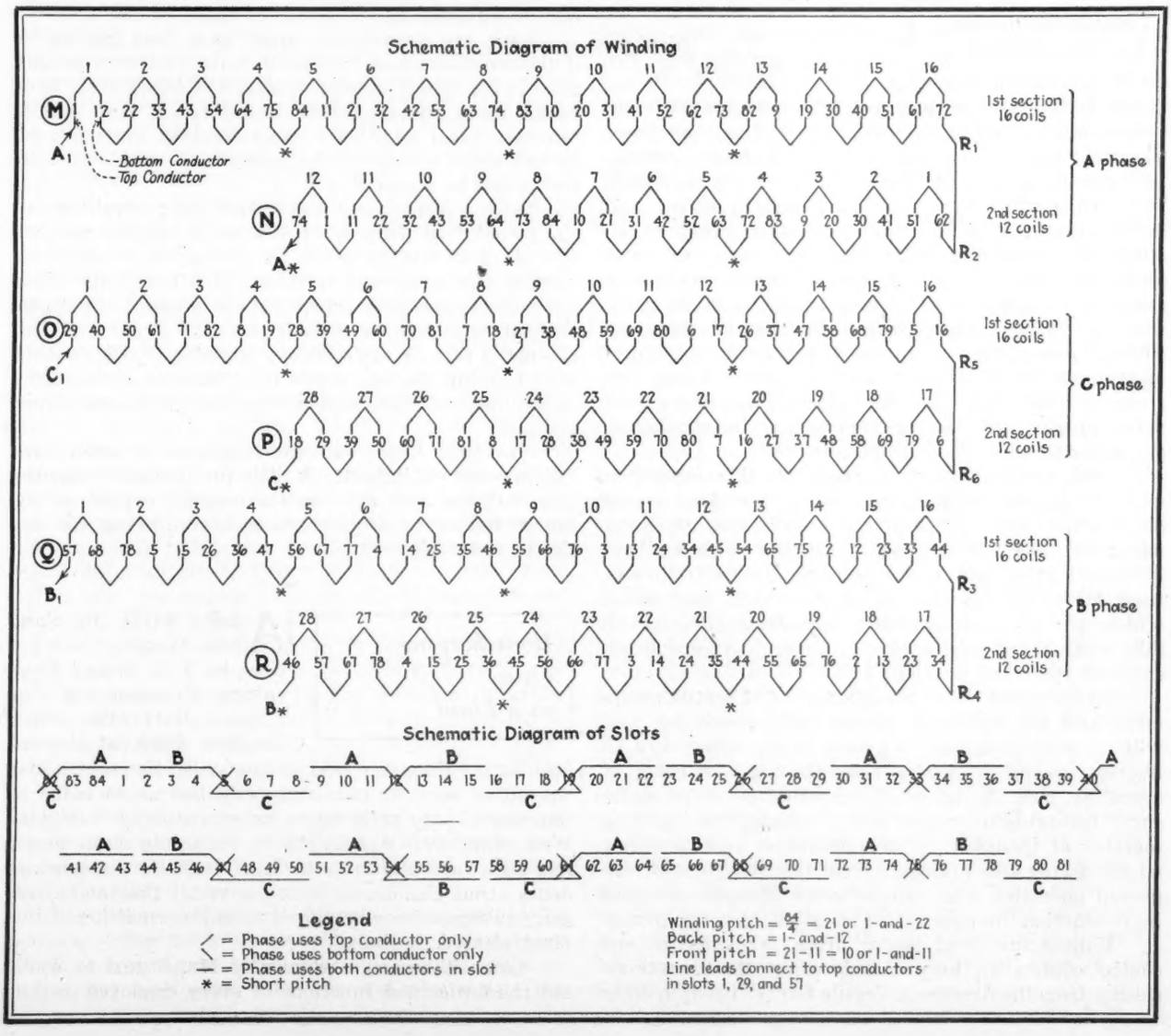
Since the line leads are to have 120-deg. spacing and since the A phase starts in slot *1*, the B phase will start in slot $(84 \div 3) + 1 =$ slot *29* and the C phase will start in $29 + 28 =$ slot *57*.

Lay out the B and C phases in the same manner as the A phase is shown at *M* and *N*. This is done in *O*, *P*, *Q*, and *R* of Fig. 2. Starting at slot *29* for the C phase we check through the winding in the same manner as was done for the A phase and locate the phase-overlapping belt. The same is done for the B phase starting with slot *57*.

This type of winding can be connected only in series, for the coils per section are not equal and if the coils were paralleled circulating currents would be set up.

Fig. 2—This diagram shows the method of laying out wave windings where the number of slots is not a multiple of the number of poles.

The upper diagram shows the schematic layout of the sections. The lower diagram shows the overlapping of the phase belts (at intersection of diagonal lines), which must occur to the sections having unequal numbers of coils.


Schematic Diagram of Winding
1st section 16 coils
2nd section 12 coils
A phase
C phase
B phase
Bottom Conductor
Top Conductor
Schematic Diagram of Slots
Legend
/ = Phase uses top conductor only
\ = Phase uses bottom conductor only
— = Phase uses both conductors in slot
* = Short pitch
Winding pitch = 84/4 = 21 or 1-and-22
Back pitch = 1-and-12
Front pitch = 21-11 = 10 or 1-and-11
Line leads connect to top conductors in slots 1, 29, and 57

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

DANIEL H. BRAYMER
Editorial Director

Assisted by

G. A. VAN BRUNT F. E GOODING A. J. WHITCOMB

Chicago, December, 1924

A Lesson from the Southern Textile Exposition

FEW opportunities are offered men in charge of industrial operations to study new developments in equipment and processes comparable with the textile exposition held this year at Greenville, S. C., except at the machinery exposition associated with the annual meeting of the Association of Iron and Steel Electrical Engineers and the National Safety Congress. This year at Greenville, S. C., Oct. 20 to 25, the Sixth Southern Textile Exposition surpassed in extent and nature anything of the kind heretofore held. Operators visiting the exhibition hall could see in actual operation practically every type of textile machinery made by seventy-five exhibitors, with the latest practice for its operation through the use of the most efficient power drive, transmission and control equipment made by 114 other manufacturers. These 189 exhibits were supervised by experts who were prepared to give practical answers to any installation or operating problem that might come up.

From the standpoint of operators this exposition was of marked educational value, for they could observe the performance of the newer types of equipment they are not thoroughly familiar with and get first-hand information on operating details from representatives of the manufacturers whom they would seldom see and thus establish acquaintances that will take away the formal nature of future correspondence on their operating problems.

On the other hand, manufacturers of textile equipment and the auxiliary drives and accessories used with it, could not hope to create in any other way an interest among anywhere near the same number of operating men in the brief period of six days under such favorable circumstances; namely, the getting together of thousands of mill engineers and operators, all discussing like problems from the viewpoint of improved operation and reduced costs through revisions in production processes that require new equipment.

Manufacturers of power drive, transmission and control equipment can profitably direct the benefits resulting from the Greenville Textile Exposition into other industrial fields, such as for instance, the wood-working field, paper making, and the manufacture of products made up of many small parts, where the problems in operation depend upon a maximum rate of production and high efficiency of equipment used with interruptions from breakdowns reduced to the last notch. Operators in these fields would welcome a comprehensive exhibit of the latest practices that are possible in new and revamped installations. Let us hope that the Southern Textile Exposition will be the stimulus for manufacturers to start something of this sort of interest to operators as an annual event in the other fields mentioned.

Standardize Your Resistors

THE problem of standardizing resistors has been with us a long time, but thus far little headway has been noticeable. Possibly an extreme case of the cost of not standardizing resistors was found in a new mill having about twenty-four automatic controllers. Each controller had from four to eight frames of resistance and for some unknown reason, no two of these frames were duplicates. To secure adequate protection against resistor failure it was necessary to purchase $1,000 worth of spare resistors.

Such an expenditure could have been prevented if the purchaser had insisted that the resistors be supplied in the fewest number of sizes and capacities. This would mean using oversize resistors in some cases, but this small additional cost would be overbalanced by the great saving in the amount of spare resistors that would be required.

Several plants have proved that their requirements can be satisfied with only five sizes of resistor frames. One operator intends to use five frames, each one to be painted with a distinctive color. If a red frame fails, the motor inspector's helper puts in a spare red frame without any fuss or trouble and the beauty of the scheme is that he can't make a mistake. Contrast this with hunting through a pile of a hundred or more resistors for one frame that is only slightly different from the rest.

The time to standardize resistance is when purchasing new equipment. A little forethought expended then will not only save on the original capital outlay but in the extent of production delays throughout the life of the equipment.

Housekeeping Costs in a Plant

A LESSON in plant housekeeping was cited by J. J. Stunzi, Consulting Engineer for the Lancaster (Pa.) Steel Products Corp. at the recent Safety Congress held at Louisville, Ky., which had the dollar sign so intimately attached as to make it impressive. He referred to an executive of a Middle West plant who was finicky in regard to clean floors and stairways and "raised Cain" with the superintendents about cleanliness with the result that more and more sweepers were employed until the condition of the plant pleased the boss.

Later it became the duty of Mr. Stunzi to write out the duties and functions of every employee in this

plant from the general manager down to the last sweeper, to determine the normal number of employees necessary for normal production. The results were interesting and surprising, for they showed where little and much work was being done. In the case of the sweepers, thirty-three had been employed but after studying their work and properly distributing it, it was found that seven sweepers could do the work of the thirty-three and did do it with a slight bonus in addition to normal pay. The saving to the company on this item alone was $27,000 in one year.

This is information enough to indicate the need of proper organization, analysis and supervision of the service about a plant that comes under the head of plant housecleaning and includes janitors, movers, sweepers, watchmen and the like.

Co-ordinating Plant Layout With Production

IN AN address delivered in Chicago, Ill., during the recent observance of Management Week by the local engineering societies, C. G. Stoll, Works Manager of the Hawthorne Works of the Western Electric Company, touched upon some practical points having to do with the co-ordination of plant layout with production. In opening his address Mr. Stoll said:

> Co-ordinating plant layout with production is primarily a problem of making an original plan that is sufficiently comprehensive to include the broad general solution of all the problems involved—that is, sufficiently flexible to adapt itself to changeable conditions without altering its essential character—and that looks far enough into the future to prevent any possibility of a costly, short-sighted use of the factory's capital and facilities.

Just what is included within the scope of these remarks and the responsibility of such a job as supervised by the author at the Hawthorne Works is best appreciated by reviewing the operations incidental to the production of the products turned out at that plant. They include: wood and metal working, glass making, textile dyeing, manufacture of lead pipe for cables, porcelain, vulcanized and phenolized fibre, rubber in sheet, rod, tube and molded shapes, the insulation of wire with textiles, making of enamels and insulating papers, and the conversion of copper billets into the finest of wires by rod-rolling and wire-drawing processes. These processes are side issues or incidental to the processes and operations that actually produce 110,000 different kinds of parts made from 18,000 different kinds, sizes and shapes of raw material in the assembling of over 13,000 separate and distinct forms of apparatus.

These figures, associated with the fact that over eighty acres of floor space is devoted to the production of these products, furnish sufficient information to impress the fact that without co-ordination of plant layout with production, nothing short of hopeless confusion could be expected. The whole problem is reduced to simple elements, however, through the co-operative functioning of seven divisions of the manufacturing organization, which are: the technical, production, operating, inspection, industrial relations, clerical and development branches.

The first or technical branch, which might be called in other work the specification or engineering division, determines how operations should be conducted and *with what* materials and equipment; the production branch determines *when* and *how much* output is required, while the operating branch is the *do it* department, which comprises all the actual producing departments and follows the instructions of the first two branches. The inspection branch operates all the inspection facilities of the works; the industrial relations branch has to do with the human side of the business; the clerical branch determines and specifies the detail routines by which work shall be conducted in order that a definite accounting procedure may be followed, figures the payroll, the costs of the products, pays for purchases, and so on, while the development branch is set aside for research and development of manufacturing processes and equipment.

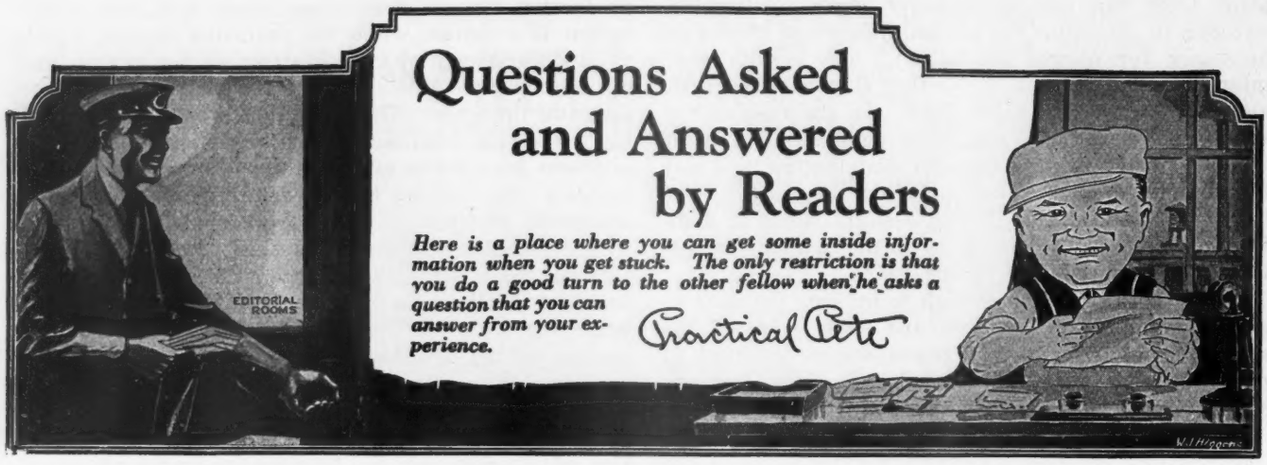
Thus it is seen that what appears from its scope to be an intricate production problem is reduced to simple elements that mainly depend on the concentration of responsibility for various functional phases of manufacturing activity into definite branches, each under the direction of a superintendent working with and not independently of other unit branches. This plan will bear careful study and application in many other lines of industrial work that call for departmental activities and the assignment of responsibility therefor.

Use Better Limit Switches

SHOULD we use crane-hoist limit switches and what should we expect of them? Arguments were advanced on the floor of a recent convention of plant engineers that it is better to do without limit switches and trust to the skill of high-grade operators. This is quite possibly true where use is made of makeshift limit switches that are liabilities rather than safety devices. But even so, high-grade operators are not infallible. Moreover, the control might jam, thus preventing the operator from shutting off power in time to prevent expensive damage and resulting shutdowns.

A recent accident in a large steel plant bears out this point. This plant is equipped with cranes of various ages, each crane having a limit switch representing the best thought of its day. Nothing had been done towards putting in modern limit switches. Dependence was placed on the limit switch in use and the skill of the operator. Eventually the time came when the operator made a mistake, the limit switch did not correct it and the load fell on a control pulpit below. The results were serious. The man in the pulpit was permanently disabled, the control in the pulpit was demolished, and the mill was tied up for four hours during a rush period. The crane was out of service for nearly a day. Needless to say, this plant is replacing their obsolete homemade limit switches with modern types and henceforth is not going to rely on the operator to stop the hoist motion of a crane at the upper limit of travel.

The solution of the limit switch problem is to obtain the very best switch that can be bought. A boiler is protected by a safety valve that is *not* a homemade contrivance. The design of the safety valve is very carefully worked out, tested and proven. Moreover, it is frequently inspected and given service tests. Can we afford to be satisfied with anything less in the case of a limit switch? Even though equipment be properly installed it does not necessarily follow that it will always stay that way.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Who Can Answer These?

Determining Size of Conductors for Intermittent-Rated Motors—Will some reader of INDUSTRIAL ENGINEER please give a method of computing the sizes of rubber-covered cables to be used for connecting intermittent-rated motors—particularly half-hour rated crane motors?
Montreal, Can. F. P.

* * * *

Voltage Rating of Fuses for 440-Volt Circuits—Will some reader please advise me as to the proper kind of fuses and fuse cutouts to use on 440-volt, three-phase, 60-cycle circuits? Should I use 600-volt or 250-volt fuses and cutouts? (2) Is it practicable to use fuses above 300-amp. rating as entrance fuses, or would it be better to use a circuit breaker?

Any information that you can give me will be greatly appreciated.
Marion, Ohio. G. R. K.

* * * *

Using Steam Engine as Air Compressor—I should like to know if it is possible, or practicable, to convert a steam engine into an air compressor. If so, what changes will have to be made and what will be the approximate cost? This is a 20-hp. engine mounted on a 25-hp boiler. The engine is of no use to me now, but I could use it to good advantage as an air compressor, driving it with a motor, with the boiler serving as the air tank. I shall appreciate any suggestions you can give me.
Accord, N. Y. H. D. V.

* * * *

Should Coils Be Purchased or Made in the Repair Shop?—We have in our plant about 1,000 motors ranging from 3 hp. to 100 hp. Roughly, one-third of these are older-type motors, while the remainder are of modern type. We have our repair shop, but so far have not attempted to wind our own coils. There is a feeling that we should do this, but before making any decision I should like to get the opinions of readers of INDUSTRIAL ENGINEER on the feasibility of doing this work. Will it pay us to do it? Can anyone give me some idea of the nature and approximate cost of the equipment needed?

I shall be very grateful for any information or suggestions you can give me.
Chicago, Ill. L. A. M.

* * * *

Method of Lining Up Conduit on Ceiling Beams—I wish some reader would please tell me the quickest and proper way to line up ½-in. conduit on the ceilings of mill-type buildings when you are breaking around the beams, using condulet fittings only at the bottom of the beams and also between beams, for lights. Some say it is best to put all of the pipe clips up first by using a chalk line and plumbing down; then you can take the line down and it will be out of the way. Others say to snap the line and take it down, but this method does not make a mark between the beams. As the thickness of the fittings must be taken into consideration, should one go by the edge of the fittings, by the edge of the pipe or by the center of the pipe? Also, should the clips be put up first, or is anything gained by so doing?
Worcester, Mass. R. S. T.

* * * *

Method of Driving One Generator with Two Engines—Can some reader suggest a practical and efficient method of driving a 50-kw. alternator by two oil engines of 37½ hp. and 50 hp., respectively, so that either or both engines may be used singly or together? If it is possible to devise such a drive with these engines operating singly or together I would have a selection of three horsepower capacities, 37½, 50 87½, with which to meet the power demands. The peak load is about 45 kw., but the load is often much less than this. With such an arrangement it would not be necessary for me to buy a second alternator and install synchronizing equipment.

I shall be very grateful for any advice or suggestions you can give me.
Youngstown, Alta., Can. W. C. A.

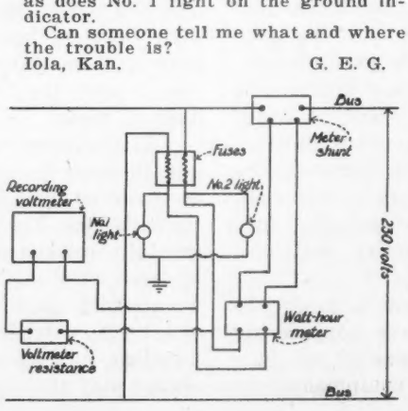
* * * *

Trouble with Switchboard Instruments—The diagram shows a section of our switchboard with which we are having considerable trouble. The watt-hour meter slows down and the recording voltmeter registers 180 volts when the voltmeter is put in circuit. However, the watt-hour meter runs normally when the recording voltmeter is cut out of circuit. I removed the voltmeter and found it tested O. K., as does the watt-hour meter.

No. 2 light on the ground indicator burns at full brilliancy on account of a ground on the meter circuit, which can not be traced out because the plant operates 24 hrs. a day. No. 1 light does not burn.

When a test light is put across the voltmeter terminals, with the voltmeter cut out of circuit, it burns dimly, as does No. 1 light on the ground indicator.

Can someone tell me what and where the trouble is?
Iola, Kan. G. E. G.



Answers Received To Questions Asked

Removing Concrete Foundations by Blasting—We want to remove the foundation of a large engine and I should like to have the experience of other readers in removing foundations by explosives or in other ways. How can I keep down the concrete dust while drilling the foundation? If we blast the foundation how can I keep pieces from flying and damaging nearby machines? Will it be necessary to take the windows out? What explosive works best and how much should be used for a shot? I shall appreciate any suggestions you can give me.
Detroit, Mich. A. H.

In reply to the inquiry by A. H. in the October issue, a short time ago we removed a large concrete engine foundation by blasting and the method used was as follows:

Starting at the edge of the foundation and about 1 ft. in from the edge we drilled a series of holes approximately 2 in. in diameter and 18 in. deep, spaced about 3 ft. apart. We used a pneumatic rock drill for putting down the holes and 2 min. was about the average time required per hole. Ordinary black powder was used. The size of the charge used was from one to two ounces. This can be determined to suit conditions by starting with a very small charge and increasing until the desired effect is produced. The holes were blown out with air after drilling, and the charge placed in the bottom of the hole. A wad of paper was rammed on top of it and then the balance of the hole filled with earth, well rammed. We have tried both the time fuse and the electric fuse and find the latter much to be preferred.

We always have plenty of old fibre cartridge fuse cases around and we utilized these for the charges. A fuse was made up by twisting two No. 16 fixture wires together, the pieces being about 10 ft. long. The wires at one end were joined by a piece of 2-amp fuse wire about 1 in. long; the other ends of the wire were joined to a flexible cord with a plug at the end to fit a standard lamp socket. The end with the fuse wire attached was inserted in one end of the old fuse shell by removing the cap at one end. The powder charge was then poured in and after making sure that the fuse wire was covered by the powder, the end of the shell was plugged with paper.

After the charge was in place and the hole plugged a mattress was placed over the hole. This mattress consisted

of a light wood frame covered with several thicknesses of burlap. In size it was about 8 ft. square. We held the frame down by placing a few sand bags along the edges. The charge was exploded by screwing the plug into a convenient lamp socket and turning on the current. The plug should be removed after each "shot" for safety to prevent the possibility of a premature discharge through someone accidentally turning it on.

The burlap mattress will keep the pieces from flying and if wetted will stop most of the dust. If the shots are gaged right there will be no necessity of removing the windows.

We blasted for a week in one of our departments which was in full production, and had no trouble whatsoever, with holding up of production, broken glass, damaged machinery or personal injury. L. J. CLAYTON.
Ass't. Mechanical Engineer,
The Goodyear Tire & Rubber Co. of Canada, Ltd.,
Bowmanville, Ont., Can.

* * * *

Selection and Application of Carbon Brushes—Can any of the readers of INDUSTRIAL ENGINEER give me any information on how to choose and properly apply the various grades of carbon brushes? I should like to know how a practical man can by inspection and simple tests choose a suitable brush for a job or determine what application a certain brush is most suitable for. I have seen references to the electrolytic action between brass collector rings and carbon brushes and should like to know the cause of this action and if there are any means of overcoming it.
W. A. P.
Smooth Rock Falls, Ont., Can.

Referring to W. A. P.'s question in a recent issue, it is impossible by inpection and tests to determine with 100 per cent accuracy a suitable brush for a job. This is proven by the fact that large manufacturers of electrical apparatus make extensive tests in selecting proper brushes for use in their machines.

It is important that the brush be of sufficient carrying capacity and the contact drop sufficiently high to reduce short-circuit currents in the coils to a minimum. In general, for stationary, flush-mica machines with speeds up to 3,000 ft. per min. a carbon-graphite brush containing sufficient abrasive to keep the mica flush with the bars is satisfactory. For stationary undercut machines an absolutely non-abrasive electro-graphitic brush should be used. On high-speed slip rings, where absolutely no cutting or wearing of rings are essential factors, a medium-resistance graphite brush is suitable. For rings of rotary converters and slip-ring induction motors where the current density exceeds 75 amp. per sq. in. a metal-composition grade of high carrying capacity must be selected.

The average user of carbon brushes gives little thought to spring tension. This is of supreme importance for an ideal brush may be ruined by insufficient pressure against the revolving part. As a rule an increase in spring tension increases the brush friction, but at the same time gives a lower contact drop. Consequently in giving a figure for brush pressure both of these losses must be considered and the value given be a compromise between the two. In general use the lowest brush pressure that will give good contact. This is seldom below 1¾ lb. per sq. in. Few brush manufacturers agree exactly as to the proper spring tension necessary for certain classes of work. This is because various constituents of a brush determine to a large degree the correct pressure regardless of the duty to be performed. For this reason it is advisable to consult the brush manufacturer.
Stackpole Carbon Co.,
St. Marys, Pa. C. O. BENSON.

* * * *

Method of Checking Alignment of Lineshafting—We have two long, and several shorter lengths of lineshafting which I know is somewhat out of line, probably due to settling of the building. I shall appreciate it very much if someone will give me a simple method of lining up these shafts accurately in the hangers, so as to reduce friction in the hanger bearings.
Milwaukee, Wis. S. V. B.

In reply to S. V. B. in the October issue, when aligning shafting without any special equipment I would suggest that he first run a line parallel to the shaft at the same distance from the floor as the center of the shaft, and as near the shaft as it can be conveniently put, and yet clear all hangers and pulleys. Have this line exactly the same distance from the center of the shaft at each end.

Then, using an ordinary carpenter's level and a straight-edge equal in length to the distance between the hangers, start at one end of the shaft and by means of the straight-edge and level find out how much, if any, the second hanger is higher or lower than the first. Also measure over to the line and determine if this hanger is out to the right or left, and if so how much.

Now using a chart prepared as shown in the illustration, proceed the entire length of the line, and obtain the position of the shaft at each hanger.

You can then examine each hanger and decide if it is practicable to put it where the chart calls for. In some cases it may be easier to raise or lower the entire shaft, or to move it sideways slightly. If you find the shafting so much out of level that it would be too expensive to make it level, it may be "graded in."

To do this divide the amount which one end must be lower than the other, by the number of spaces between the hangers, which will give the amount that each hanger must be higher or lower (depending on whether you start at the low end or the high one) than the one before it.

After the shaft has been put in the proper position, according to the chart, go over it once more as a check upon the accuracy of the work.

When the shafting in a plant is periodically aligned, file the charts away for future reference; then by comparing a number of charts obtained from any one length of shaft it can be determined if any of the hangers have been out of line in the same direction each time, and if so, the trouble can be located and remedied.
Head Machinist, DONALD MAXFIELD.
Old Town Woolen Co.,
Guilford, Me.

LOCATION-_____
DATE-_____

Hanger No.	High	Level	Low	Right	Line	Left
1		X			X	
2	3/16"				X	
3	1/8"					1/4"
4			1/8"			1/8"
5			3/16"		X	
6			1/4"	1/8"		
7			1/8"	3/16"		
8		X			X	
9		X				1/8"
10		X			X	

This chart is used to record the data taken when checking the alignment of shafting.

* * * *

Can Direct Current Be Obtained from Ford Spark Coil?—Will some reader please tell me (1) if I can connect a Ford spark coil to a 110-volt line through a 6-volt, step-down transformer and use it for the ignition system of an engine? (2) Under these circumstances would the high-tension side of the coil deliver a.c. or d.c.? (3) What is the voltage on the high-tension side of one of these coils? (4) Can I put 110 volts a.c. on the high-tension side and charge a storage battery from the low-tension side? (5) Can you tell me how to make a good rectifier for charging storage batteries?
Bellingham, Wash. E. M. D.

In answer to the question by E. M. D. in a recent issue of INDUSTRIAL ENGINEER, I would say (1) you can use a Ford coil for ignition and get good results.

(2) Alternating current, but not of true sine-wave form.

(3) From 10,000 to 15,000 volts, through interrupter adjustment. Higher voltages can be obtained by increasing the voltage of the primary supply, but this will soon burn out the contact points.

(4) No, because the current is a.c. Even if rectified this current from the low-tension side of the Ford coil (provided the coil is connected as you describe) would be too weak for charging storage batteries. The current for charging storage batteries must be d.c., either continuous or pulsating.

(5) Directions for making a rectifier for charging storage batteries can be found in some of the books containing instructions for making wireless telephones.
Concord, Mass. DONALD FERGUSON.

* * * *

How Does the Lundell Motor Operate?—Can some reader of INDUSTRIAL ENGINEER give me a simple explanation of the theory of operation of the Lundell d.c. motor made by the Sprague Electric Co.? This motor has only one field coil (either series or shunt) which is placed in the frame in such a position that the armature rotates in the center of the coil. In other words, the field coil is wound around the armature.

I should like to know how and where the magnetic field poles are formed.
Philadelphia, Pa. C. F. S.

Replying to the question by C. F. S. in the October issue, if he will examine the motor in question he will notice that it is a two-pole machine. The field frame splits in two at an angle of 90 deg. to the armature shaft, with one pole piece cast on each half in such way as to hold the field winding in the frame at about a 70 deg. angle to the armature, allowing one pole piece to come in on either side of the field coil and making a north and a south pole.

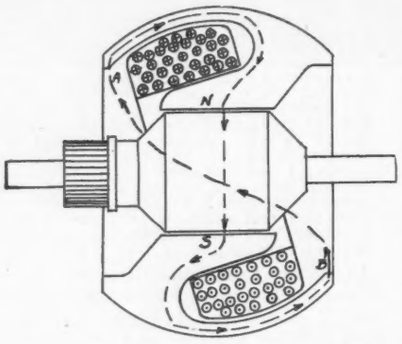
This style of field winding eliminates any chance of wrong field connections

except when the machine is compound wound, in which case it would be as easy to get the windings opposed as in any other type of motor.

Middleport, Ohio. ELZA HERRMANN.

* * * *

The question asked by C. F. S. in the October issue is answered by reference to the accompanying diagram. The peculiar form of a single-coil, bi-polar field system used in this motor gives two salient poles from a single coil. Each of these poles is diametrically opposite to the other. The magnetic circuit is outlined in the diagram by the dotted line.



Magnetic circuit of Sprague round-type single coil, bi-polar motor.

With the current in the field coil as indicated (flowing into the paper at the crosses, upper section, and coming out at the dots, lower section), the lines of magnetic force follow the path from one pole to the other through the armature core, and return from (B) to (A) through the frame. There occurs also a leakage of these lines from the tips of the poles to the points (A) and (B), but since this gap is quite large the amount of leakage is comparatively small.

Honesdale, Pa. J. M. WALSH.

* * * *

Method of Running Open Wiring in Mill-Type Buildings—I wish some of the readers of INDUSTRIAL ENGINEER would give me their opinion on the best way of running open wiring in buildings of mill-type construction. Assuming that No. 8 or larger conductors are used, should these be run on the roof trusses, on the ceiling beams or on the side walls? Should the conductors be supported by cleats or on knobs? What kind of cleats and knobs should be used? I should also like to know when and how strain insulators should and should not be used. Is there any preference as to the type of strain insulator? Any information you can give me will be much appreciated.

Worcester, Mass. R. S. T.

Referring to R. S. T.'s question in the September issue, the following materials have been used with success for open wiring in the roof trusses of mill-type buildings. For small wires the most useful combination has been standard No. 4½ porcelain insulators on Universal No. 501 insulator supports. For medium-sized wires the Peirce wireholders are very useful. For cables an excellent job can be done with Peirce secondary racks at intermediate supports and Giant strain insulators at end supports. The most satisfactory place for fixing the supports is on the bottom chord which is the lowest horizontal member of the roof truss, but if piping or the building structure prevents, another member may be used. No hole should be drilled in the structural steel. The racks can be fixed in place by bolts passing through between the longest members of the racks and between the angles of the roof truss member. The strain insulators should be attached to a rectangular bar forged in the shape of a hook conforming to the section of the structural member of the building which is to take the strain. D. W. BLAKESLEE.

Electrical Engineer,
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

In answer to R. S. T.'s question in the September issue, the roof trusses usually make the best support for large wires and cables; here they are less likely to be injured and a clear space can usually be found that is accessible. When conductors are supported on the ceiling beams, they are generally in the way of shaft hangers and the rigging used when handling machinery on the mill floor.

Wires should be supported by single-wire cleats secured by wooden screws or lag bolts. It is advisable to line out one row of cleats with a chalk line. With the larger cleats it will be found much easier to start the screw if small holes are bored in the beams with a gimlet bit. A sheet-iron templet can be easily made for marking these holes and will be well worth the time spent in making it by the improved appearance of the rows of cleats.

All heavy wires and cables should be secured to strain insulators at dead ends. A convenient method of doing this is by the use of G. E. strain clamps or Matthews feeder clamps to hold the cables. The strain insulators should be anchored by long-thread eye-bolts so that the tension on the wires can be equalized. A strain insulator of the Giant strain type has been found very satisfactory by the writer.

Where steel frame construction is used the cleats should be secured to wooden pieces bolted to the roof trusses. These pieces should be at least 1½ in. thick.

Charleston, W. Va. EDWIN C. BIRGE.

* * * *

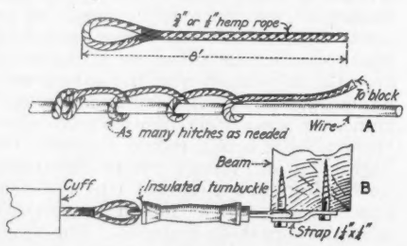
In answer to R. S. T.'s question in the September issue, open wiring is permissible in mill buildings, but the work must be very neat. No. 8 wire or larger does not require supports every 4½ ft. as smaller conductors do. Accordingly it may be supported at every beam. Rubber covered wire may be used, or cambric insulated if the voltage is high enough to warrant it. I would suggest asbestos covered (white wire) if low voltage is used. If the building in question is a cotton mill, asbestos-covered wire will make an installation that harmonizes with the surroundings. All wires must be installed on the under side of beams or trusses. I would suggest using split porcelain cleats provided with two holes for screws. Round head, blued wood screws or galvanized lags make a neat installation, and they do not burst cleats as flat head screws do. The proper size of cleats for a certain size of wire and insulation may be obtained from any electrical dealer's catalog.

For short spans, not over 100 ft., use plain strain insulators at one end and insulated turnbuckles at the other. The wire should be served directly into the strain insulators and turnbuckles, if it is not too large; if it is too large a link can be used. In spans of 125 ft. or more I would use insulated turnbuckles on both ends of the line.

After deciding on the length of line serve strain insulator to wire and then reel off the proper length, allowing for serve to insulated turnbuckle.

Procure a light, stout staging and "pull a line" under beams or trusses about 50 ft. long. Take a square, combination preferred, and mark the center of each cleat, usually about 6 in. apart. The holes may be laid off and a drill of the right size used to drill the holes before attempting to fasten up the wire. If neatness is not essential the wire may be pulled up fairly tight with turnbuckles and the cleats put on.

When the holes are all drilled the strain insulators are fastened and a cleat put loosely on every other beam to hold up the slack in the wire. The eyes of the turnbuckles are then fastened at the other end of the line. A rope hitch is made around the wire and a chain or rope block is used to haul up the slack. The wire is pulled taut and the turnbuckle is let out until only one or two threads hold. The wire is measured for the serve and the block slacked off. It usually saves time to serve on the floor or where the electrician or helper is fairly comfortable. When the nut end of the buckle is served on it is pulled into place by blocks and two or three threads are caught. The blocks are removed and all cleats are put on loosely; when this is done the buckles are tightened to suit, the tighter the better unless exposed to cold or snow and ice.



How rope hitch is made, A, and method of fastening strain insulators and turnbuckles, B.

Fiber cuffs can be used to insulate serves unless a high voltage is used. A 3-in. cuff about 18 in. long is sufficient. Cuffs must be placed on the wire before fastening up and they are very easy to forget. I would suggest using some form of solderless cable tap, (I prefer Dosserts) for making taps. They are much neater than a splice or ordinary screw tap. A brace or power screwdriver or socket wrench for the lags will speed up tightening of the cleats.

The reason for using a rope to pull up slack wire is that it does not cut or

mar the insulation and a cable basket cannot be used very well in this case. Plain wood strain insulators are generally used but many suitable types are listed in dealers' catalogs. The illustration shows the method of fastening strain insulators and turnbuckles and also the rope hitch.

Any mechanic who puts a line up in the above manner will have a line that is straight and neat if he is reasonably careful in lining up the cleats.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Replying to R. S. T.'s question in the September issue, I always prefer to run open wiring, as well as conduit, on the ceiling or roof trusses. In the first place I am able to space the conductors better than when I run them on the side walls. Also, they can be strung tighter, which makes a neater job. Conductors, when run on the ceiling, can as a rule be supported at shorter intervals. Of course, that all depends on the general layout of the job.

I prefer single-conductor, split-type cleats. As regards using strain insulators, I use these on heavy conductors where I have to change from a vertical to a horizontal run inside of buildings where I can support the conductors at longer intervals in order to take the strain off the cleats.

For smaller conductors I use two or three cleats as strain insulators. At the ends of the runs I generally use the Peirce insulated fork and turnbuckle as a strain insulator. By using a turnbuckle it is possible to draw the conductors tighter than can be done by using a block and tackle only.

I hope that these suggestions will help R. S. T. in his problem.

Chicago, Ill. A. NOEPPEL.

* * * *

Jackshaft Bearing of Mill-Type Motor Leaks Oil.—I am having trouble with oil leakage from the jackshaft bearings of mill-type motors. These bearings are large, running from 3½ to 7½ in. in diameter. They are split and held in brackets which are integral with the motor frame. Both ends of the babbitt bearing extend beyond the bearing housing. There is one oil ring in each bearing. The oil leaks out around the shaft at the ends of the bearings and then drips on the surrounding apparatus. At times the oil will be drawn out of the bearing to such an extent that the oil level will fall too low for the ring to dip in the oil.

I shall appreciate it if some of the readers of INDUSTRIAL ENGINEER will give me the remedies they have used to overcome this trouble.

South Chicago, Ill. O. C.

In reply to O. C.'s question in the September issue, I think he will find much improvement if he will cut a groove in each end of the bearing about ½ in. from the outer end and then cut lateral or diagonal grooves back to the center of the bearing and there provide a hole for the oil to drain back to the housing again. The groove around the bearing near the ends should be about $\frac{1}{16}$ in. wide and $\frac{1}{16}$ in. deep and be made with a round-nosed tool in a lathe. The other grooves will no doubt, have to be cut by hand with a sharp, round-nosed chisel or tool made purposely for the job. It will not be necessary to cut diagonal grooves in the top half of the bearing, as the oil on top will be drained to the bottom by the grooves cut around at each end.

Donnacona, P. Q., Can. LEE F. DANN.

* * * *

Referring to the question in the September issue, Keystone grease, No. 6 light density, has in many plants replaced oil for the lubrication of ring oil bearings, due to its ability to maintain its original consistency through a wide range of temperature. Where an oil which has the proper viscosity for this class of lubrication, thins down and begins to creep along the shaft and out of the bearing at temperatures of say 110 deg. F., to 130 deg. F., the liquid grease is not affected by the heat, and therefore, stays in the bearing.

Granting that mechanical conditions are right, it seems to us that a trial of this lubricant would largely overcome the trouble.

No. 6 Light is wholly liquid and is made expressly for ring oil bearings, but as before stated it is unlike oil in that it will resist a wider temperature range without an alteration of its original density. F. D. STREET.

Sales Engineering Dept.,
Keystone Lubricating Company,
Philadelphia, Pa.

* * * *

Is it Good Practice to Weld the Bars in Squirrel-Cage Rotors?—We have a Westinghouse type CCL 2-hp., 1,200-r.p.m., 220-volt, three-phase motor, whose rotor bars were fastened to the end rings with one screw and soldered, and were insulated in the slots with fishpaper. This motor drives an air compressor and is controlled automatically. Recently it failed to start when the switch was closed and when it was discovered the winding was roasted, the solder had run out of the rotor and the slot insulation was destroyed.

The motor was rewound and the rotor welded. The bars were not insulated again. The screws holding the bars were left in and the spaces between the ends of the bars were filled clear up with Tobin bronze. Now the motor refuses to start the load, but carries it nicely after it is once started. The winding is the same as before and there are no hot spots in either stator or rotor. I took a light cut off the end rings, but this made the motor weaker.

I believe the rotor bars need slot insulation, but it will be a big job to cut off the weld and make new bars. Does welding these rotors usually cause this trouble? Previous to this I had always reinsulated and soldered the bars and had no trouble. If welding is good practice I want to do it, but if it is not I want to leave it alone. Any information you can give me will be much appreciated.

Also, can you tell me where I can get felt wicking, such as is used in the oil cups of small motors?

Regina, Sask., Can. G. D.

Replying to G. D. in the September issue, it has been our practice for several years to weld all rotors which come in with the solder thrown out. As a matter of fact, welded rotors have superseded soldered rotors entirely. I believe G. D.'s trouble lies in the fact that he filled in the space between bars with the new metal. This had the effect of increasing the section of the end rings, thereby reducing the resistance in the squirrel-cage winding. This in turn reduced the starting torque of the motor.

When welding CCL rotors it is our practice to weld only along the bottom edge of the bar and not fill in the space between bars. Since it will probably be difficult to remove the Tobin bronze from between the bars I would advise G. D. to take another good cut off the end rings and thus reduce the cross section.

With reference to the slot insulation on the rotor bars, the current induced in the squirrel-cage winding is of such low voltage that there is no tendency for it to travel into the iron and for this reason insulation is not used on present-day squirrel-cage windings.

I would advise him to apply to the motor manufacturer for the felt wicking used in the bearings.

Walkerville, Ont., Can. R. B. TURNER.

* * * *

In answer to the question by G. D. in the September issue of INDUSTRIAL ENGINEER, I have had very good success in welding rotors and find that it does not affect the operating efficiency, providing the bars are insulated from the laminations of the rotor. In one case where the insulation was removed the motor showed in operation the same characteristics as the one in question. After the bars were reinsulated the motor operated as it should.

Another thing that I have found out about welding rotors, is that it is very essential that they be perfectly balanced after the welding in order to remove any heavy spots. Otherwise, the rotor will cause serious vibration.

Goldfield, Nev. PHIL D. COMER.

* * * *

In reply to the question by G. D. in the September issue, I once had the same trouble with a 20-hp. CCL motor. I overcame it by reinsulating the rotor bars, soldering the end rings and tightening the screws and the motor has given excellent service for the past eight years. In the type of motor he speaks of the rotor bars should be insulated allowing the secondary current to follow the path of the copper. Under present conditions, the secondary current is flowing in all directions through the rotor so that it cannot exert the required amount of twisting effort to start the load.

Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.,
Springfield, Ore.,

* * * *

G. D.'s trouble, described in the September issue, is due to the fact that the space between the rotor bars was filled in with metal flush with the top of the bars and, no doubt, extending back along the bar the width of the end ring. The result is that the end ring is shorted and a very low-resistance motor is obtained.

All of our service stations make it a practice to weld all rotors of this type, but they do not fill up the space between the bars with metal. Only a small fillet is put along the edge of the bar where it makes contact with the top surface of the end ring. After welding a light cut, $\frac{1}{16}$ in. to ⅛ in. deep, is taken off the end rings and bars in order to bring the starting torque back to normal. Welding is good practice, when it is properly done.

The only thing G. D. can do now is to chip out the metal between the bars or put a number of saw cuts in the added metal, between the bars. If this does not bring the torque back to where it

belongs, put a few saw cuts in the bars themselves. The cuts should probably be from ¼ to ⅜ in. deep.

The insulation on the bars need not be renewed as it is very seldom that the current will pass through the iron. The complete rotor can be dipped in Sterling varnish, or any good varnish that will bake hard. This will help somewhat, but is not absolutely necessary.

East Pittsburgh, Pa. A. C. ROE.

* * * *

Answering G. D.'s question in the September issue, the rotor bars should be properly insulated, as they came from the manufacturer, and every bar should have a very substantial connection with the end rings. If the screws are not enough, a thorough soldering or welding of each bar is needed.

Even in squirrel-cage motors, although the rotor carries no winding, if these bars get loose at the end rings there is trouble.

I recall one instance of a 25-hp. motor, in a large typewriter factory in Hartford, where a few bar connections loosened up, causing heat in the rotor and, as it was in the cellar, small sparks could be seen jumping from the rotor to the stator winding.

With nothing else at hand to work with except a large hand-size gasoline torch, and a small gas and air burner, the latter was used to heat a large patch of half-and-half solder all around both end rings at every bar, the rotor being partly drawn out of the frame for convenience.

After that no heating or sparking was noticed, although this motor was driving an exhaust fan 10 hr. a day, at full load.

Jamestown, N. Y. H. S. RICH.

* * * *

In answer to G. D. in the September issue, I do not think the trouble you are experiencing with your 2-hp., CCL Westinghouse motor is due to lack of insulation in the rotor. We weld rotors, both large and small, every day and never pay attention to the rotor insulation. The lack of starting torque is due to too much metal in the end rings. This will cause the motor to draw excessive current and refuse to come up to full speed.

I recently had an experience similar to yours with a 3-hp. 110-volt, G. E. motor which was rated at 16.5 amp., full load. When it came in it drew 65 amp. when running light.

The windings and connections were checked with the factory data and found to be O. K. On examination, we found that someone had welded a bronze ring on the rotor when the bars came loose. It was a neat job, but on checking over the weight of copper on the rings, we found the rotor had more weight than the stator, which does not agree with present principles of design. Generally speaking, the rotor carries about 80 per cent as much copper as is used in the stator. So we turned the excess off the rings and the motor operated satisfactorily.

On small rotors we always weld only the ends of the rings. On large rotors, we just spot the bars to the ring. We have never had any trouble and prefer welding to soldering. For welding we always try to use the same kind of material as is used in the rings or bars, so as not to change the secondary resistance materially.

I hope this information will be of some value to G. D.

NICHOLAS J. WEISS.

West New York, N. J.

* * * *

In reply to G. D.'s question in the September issue, it was all right to weld the rotor bars to the end rings as this makes a better and stronger job and no harm can be done by so doing, providing you do not add too much metal. However, I believe that in this case sufficient metal was added to the end rings to alter the resistance of the rotor materially. This would account for at least part of the trouble.

I believe that if G. D. reinsulates the bars he can overcome this trouble.

The felt wicking he mentions can be obtained from motor dealers or supply houses.

Muncie, Ind. GEORGE CROPPER.

* * * *

In answer to G. D.'s question in the September issue, I would like to say that his trouble is unusual, and seldom happens. I have seen numbers of rotors welded, practically all commercial sizes, and their operation has always been satisfactory. A slight additional heating might result but not enough to do any damage. I have removed the insulation from rotors and have seen numbers that came from the factory without any. Their operation has always been satisfactory. In the motor in question the removal of the insulation must have caused the trouble, because it would reduce the resistance and cause heating. In the case of a small motor I would think that a small amount of metal would be sufficient. In a rotor the higher the resistance, the higher the starting torque becomes, within certain limits. I would suggest that the insulation be replaced and the bars welded to a ring of the same composition and cross section as the original ring, not using any surplus metal. I am sure that this will remedy the trouble. I believe the rotor has too low resistance as it now stands. I have always observed that welding properly done is a success and many motors are coming from the factory welded.

Wicking for motors can be obtained from the manufacturer of the motor.

Birmingham, Ala. GRADY H. EMERSON.

* * * *

Use of Red Metallic on Repaired Armatures—After rewinding or repairing railway motor armatures a coating of Red Metallic and shellac is applied to certain parts—sometimes to the end of the commutator, or to the top of the bars where the leads are soldered on, to the projecting mica cone, and so on. Shellac mixed with it and applied seems to dry much quicker than straight shellac; also it makes a hard, permanent coating which has a certain cementing property, as when applied to the cone to prevent the fraying off of small mica pieces under operating conditions. However, Red Metallic is nothing but iron oxide, better known as iron rust, and is a good conductor of electricity. Therefore, I do not believe anyone, including myself, has any justification for using it, for it certainly is a conductor in the powdered state and probably is when mixed with shellac, although I have never had, or heard of, any trouble on account of its use. I use it as others do because the boss says to use it—and he does not seem to have any reason for so doing except that others before him have used it with no bad results.

Why could not the same quick-drying and cementing properties be obtained by mixing shellac with a non-conducting material such as plaster of paris or chalk? I should like to know what other readers think about the use of this systerious Red Metallic.

Oakland, Calif. S. H. S.

In the September issue, S. H. S. asked about the use of Red Metallic. We have a Sturtevant fan, the driving motor of which used to give us some trouble from shorts in the end of the commutator and burning to ground.

After replacing the micanite insulation, we gave the end of the commutator a heavy coat of Red Metallic and shellac and since then the commutator has not given any more trouble. The motor runs twenty-four hours a day and seven days a week, and since using the Red Metallic, we have had to repair the commutator only once in about three years.

San Francisco, Calif. C. H. PRATT.

* * * *

In answer to S. H. S., in the September issue I do not believe it is advisable to paint commutators as mentioned, although there may be on the market so-called oil and waterproofing preparations of which the writer does not know. Commutators and commutator parts should be purchased from the manufacturers of the motors; the copper and the mica will then be of the best. Any pits or cracks which may develop on the end surface of the commutator may be cleaned thoroughly so as to remove all oil and carbon deposits; then press into the places to be filled, asbestos crumbs and shellac, and dry with the blow torch. Pits on the working surface of the commutator and undercutting between bars, may be filled with plaster of paris mixed with water. These methods have been used with success in railway and mill-type motors in one of the largest steel and iron works.

Electrical Engineer, D. W. BLAKESLEE.
Jones & Laughlin Steel Corp.,
Pittsburgh, Pa.

* * * *

Answering S. H. S. in the September issue, I would never try to use any conducting material as a non-conductor for any purpose, much less on 500- to 650-volt trolley lines.

There are many good, substantial armature varnishes on the market for just this purpose, and no risk is attached to their use. Shellac is not proof against water to any great extent, as it is likely to crack, blister, peel and soften when wetted repeatedly, and the addition of chalk, plaster of paris or iron oxide makes the composition all the more liable to absorb moisture, the very thing it is desired to prevent.

There may be some good reason for using this compound, but for better results I would suggest that a good make of armature varnish be procured for a trial; coat one or two armatures thoroughly and repeatedly and then dry them well. Note all the facts and the date and watch their operation over a period of time. The results will likely prove more satisfactory than when other materials are used.

Jamestown, N. Y. H. S. RICH.

Meaning of Motor Nameplate Data—Can some reader tell me what "Open Hp. 10, Amps. 75,—Closed Hp. 5½, Amps. 43," means in the case of a General Electric, d. c., compound-wound motor which has the following nameplate data: No. 95790, Form B, Speed 650, Volts 115, Open Hp. 10, Amps. 75—Closed Hp. 5½, Amps. 43. Pat'd Feb. 14-88 up to Jan. 31-99.
Mazatlan, Sinaloa, Mex. J. C. L.

Answering J. C. L.'s question in a recent issue of INDUSTRIAL ENGINEER, "Open horsepower" means the horsepower rating when all ventilating openings are used, and is the highest rating. In other words, this condition gives the maximum dissipation of heat.

The term "closed horsepower" means the horsepower rating when the motor is totally enclosed. Naturally the horsepower would be lowered, because there is less chance for the heat to escape. The heat would be greater under these conditions; so the horsepower rating is lowered in order to reduce the heating to a safe value. The totally-enclosed motor is used where the materials suspended in the surrounding atmosphere are injurious, or objectionable inside the motor.
Birmingham, Ala. G. H. EMERSON.

* * * *

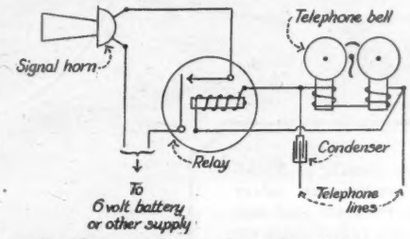
Connecting Extension Bell to Telephone—I shall appreciate it very much if readers will give me some information on the following problem. In our engine room we have a telephone which operates from the city system, through our own switchboard. When the engines are running it is impossible to hear the bell ring unless some one is standing close by the telephone. I wish, therefore, to install a large alarm or extension bell. How should this be connected? What voltage is used to ring the telephone bell? What voltage and type of bell should I use? Is it necessary to use a relay for this bell; if so, what type is preferable? Please give me a wiring diagram showing how this bell should be connected.
Chicago, Ill. W. A. B.

If W. A. B., whose question appears in the September issue, will secure a telephone relay manufactured by the Benjamin Electric Company, Chicago, Ill., and connect one side of it across the telephone line and the other side in series with a 110-volt bell across a 110-volt line, his troubles will cease. The ringing current on the telephone line energizes the relay and closes the contact on the 110-volt side, thereby ringing the bell. If he desires, he can have a 110-volt red light connected in multiple with the bell and located on the engineer's desk. The light will then call attention to the ringing of the telephone.
Chief Electrician, EARLE N. DILLARD.
Booth-Kelly Lumber Co.
Springfield, Ore.

* * * *

In reply to W. A. B., in the September issue, I would suggest that he install a signal horn instead of a large bell. In my experience, I have found horns to be far superior to bells from the standpoint of both operation and audibility. A horn can be obtained that will suit any voltage from 6 volts to 250 volts, a.c., or d.c.

For reliability of operation, it is probably best to use a six-volt storage battery on a 6-volt horn, but any reliable source of current will do, provided the voltage of the horn corresponds. A relay is nearly always required for operating the horn, the connection being as shown in the diagram. It will be seen that the coil of the relay is connected to the terminals of the telephone bell. This is essential, especially if there is a condenser in series with the bell, which is the case in most telephones. It is hard to say what voltage is used on your telephone bell, as this varies on different systems. In ordering extension bells or relays, the resistance of the bell ringers in ohms should be stated. This is usually stamped or printed on the bell coils. Of course,



Method of connecting signal horn to telephone line, for operation on a local battery through a relay.

if a bell is preferred, it can be connected in the same manner as the horn, using the same relay, and operating on a suitable voltage; or a bell can be obtained that will operate directly from the telephone bell terminals.

Any manufacturer of electric horns will supply the proper relay and directions for its installation if the system it is to be used on is described.
ERNEST DICKINSON.
Kimberley, B. C., Canada.

* * * *

In answer to W. A. B. in the September issue, if this telephone belongs to the Telephone Company nothing should be attached to it without their permission; however, they would install a bell for you, if needed. They will, of course, make an extra charge for the installation.

On the other hand, both a loud bell and a 110-volt ruby lamp could be installed to operate through a relay, the latter being made to work on the telephone line alternating ringing current, with the bell or light operated on either storage battery or city current as most convenient.

I would suggest that you write to the Western Electric Co., New York, N. Y., for such apparatus, as they make all kinds of telephone equipment.
Jamestown, N. Y. H. S. RICH.

* * * *

Answering W. A. B. in the September issue, when connecting extension bells to a telephone system, it is very necessary to ascertain the ohmic resistance of the bells in service. The usual resistance is 1,000, 1,200 or 2,500 ohms. In exchanges where the battery is common to all telephones and the operator is signaled by taking down the receiver, it is necessary to connect a condenser, usually 2 mf. capacity in series with the bell. In the case of a private line, the bells are connected in parallel with the line. If the line is a party line, ringing on the "ring" and "tip" side of the line, it will be necessary to connect one side of the bell to ground and one side to the ringing side of the line.

In case the system is of the magneto type, the condenser can be omitted and the bells connected as stated in the paragraph above.

Any manufacturer of telephone supplies can furnish a loud-ringing gong at a nominal price. The American Bell Telephone Company uses Western Electric bells almost entirely, but Kellogg and various other bells advertised in recent issues of INDUSTRIAL ENGINEER are satisfactory.
Goldfield, Nev. PHIL D. COMER.

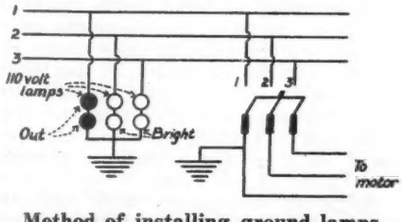
* * * *

Trouble with Traveling Cranes—I am having trouble with two traveling cranes which run on the same track and are used for loading and unloading stone in a mill. One crane is rated at 20 tons and the other at 30 tons. Each crane has two slip-ring motors of about 20-hp. rating, which operate at 220 volts, sixty cycles and are controlled by General Electric starters. When both cranes are in operation the hookers on the ground get a shock every time they touch the chains which are used to carry the load. When either one of the cranes is idle, the men do not get a shock. I have tested out all circuits with a magneto and was not able to find any indications of trouble. I shall appreciate it very much if any of the readers of INDUSTRIAL ENGINEER can tell me how to find this trouble.
Bloomington, Ind. H. M.

In reply to H. M.'s inquiry in a recent issue, it is very evident that he has two grounds, one on each crane. He fails to state, however, whether this is a two-, three- or four-wire system. I will assume, therefore, that it is a three-wire system, as this is the most commonly used in industrial crane operation.

Ground lamps should be installed in a convenient place so as to be visible from the crane cab. This is desirable from the standpoint of safety for the men as well as for the convenience of the electrician. These lamps should be installed as shown in the accompanying sketch.

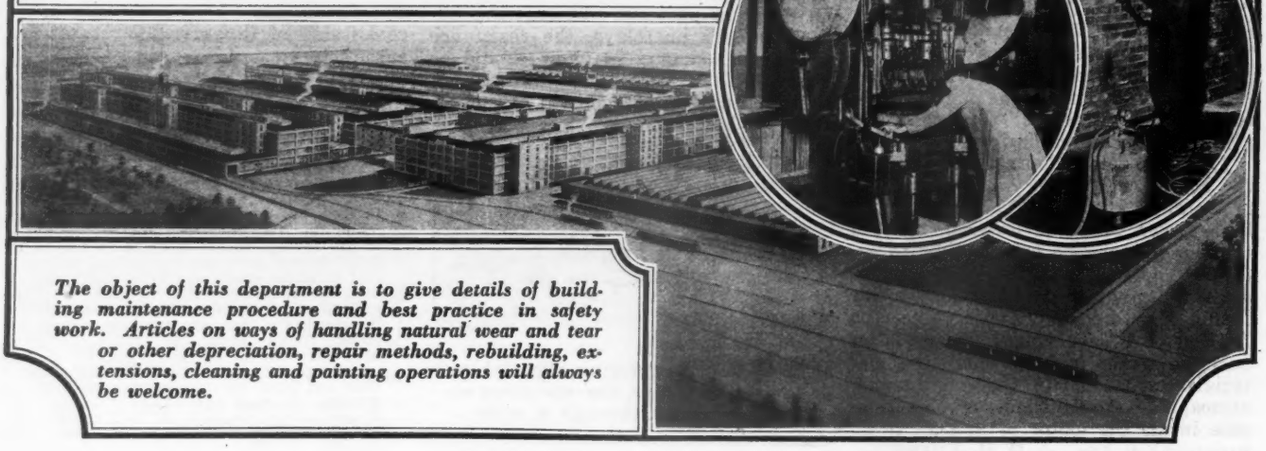
After installing the ground lamps one crane should be run with the chains on a good ground and the lights noted. If the lights go out on one phase and the lights on the other two phases brighten, the ground is on the dead phase, which can then be traced to the motor.



Method of installing ground lamps to detect grounds on crane.

After one crane is cleared up in this manner, the other crane should be treated similarly. In case the trouble cannot be found, but grounds exist, connect both of the grounded phases on the motor side of the controller to the same phase on the trolley. This can be done by changing all three wires and still not change the direction of rotation of the motor. Although this procedure is not to be recommended and should not be necessary, inasmuch as it should be possible to locate and clear up any grounds which exist, it will keep the men from getting shocks, if the ground lamps are disconnected.
East St. Louis, Ill. A. H. SUMMERS.

Building Maintenance and Plant Safety



The object of this department is to give details of building maintenance procedure and best practice in safety work. Articles on ways of handling natural wear and tear or other depreciation, repair methods, rebuilding, extensions, cleaning and painting operations will always be welcome.

Installing Many Individual Coolers Instead of General Ventilation

AN EFFECTIVE and unique ventilating system, which is installed in a bank in New York City, for supplying cool air directly to individuals in a spacious area, may be suggestive of some industrial applications, especially where it is more desirable to discharge the air near a worker than openly in the building, as is done by fans and ordinary ventilating pipes.

In the basement, just outside of the large deposit vaults, a blower fan, which is driven by a 3-hp., direct-current motor, is bolted to a concrete foundation. The blower draws fresh air from the outside of the building through an intake pipe located about 2 ft. above the walk. The open end of this pipe is covered with a fine wire gauze. A 4-in. galvanized iron pipe, with air-tight soldered joints, is carried from the 20-in. fan along the ceiling and up through the floor above to the rear of the partitions in the bank room itself. Here the pipe branches to a smaller size and is carried to the right and left along the floor at the lower edge of the partitions around three sides of the room.

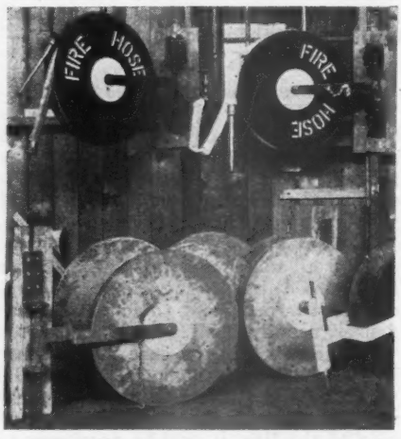
At every employee's desk and at every window a 1-in. tin pipe, similar to speaking tube, with joints tightly soldered, is carried upward from the floor. By means of a slide at the end of each pipe the amount of air can be readily regulated. As the 1-in. pipes are branched off the main distribution pipe is reduced in diameter. The pressure is just enough (I do not recall the exact pressure) to cause a steady, noiseless flow of cool air to pass out of the nozzles. On a warm, summer's day the whole room is perceptibly cool, yet no fans or other contrivance for cooling the place are visible to the patrons.

This method of supplying cool air is well liked by the employees because it is no trouble to them, and the air can be regulated by each individual to suit himself. On a warm day the janitor starts the motor and lets it run until closing time.

New Britain, Conn. H. S. RICH.

How Steel Hose Reels Reduce Maintenance Costs

HOSE reels as ordinarily used in industrial plants are made of cast-iron and are easily broken by bumps if they are located in or near a crane runway where there is trucking and handling of materials. This problem of how to prevent this breakage has been solved by F. J. Heuring, Bureau of Safety and Plant Protection at the Michigan City, Ind., plant of The Pullman Company. Here cast-iron reels for 1¼-in. fire hose, are, when broken, replaced by reels constructed of steel which can easily be straightened or repaired in case of a bump. These reels are made up of No. 10 gage steel on a 3-in. wood roller with a ¾-in. pipe through the center to serve as an axle. Center plates 10 in. in diameter and made of the same gage stock are riveted on each side of each of the two plates to give the reel additional rigidity and allow for connection with the ¾-in. threaded pipe used as an axle. The reel is suspended from the wall or post by an arm of ¾-in by 1¾-in. bar steel on a pivoting bracket, as may be seen from the illustration. Steel used in the construction of these reels is practically all taken from miscellaneous scrap materials.



When a cast-iron hose reel is broken, it is replaced by one of these special steel reels.

New York, N. Y. G. F. H.

Advantages of Proper Design in Floor Arrangement

THE columns in a building afford a convenient anchorage for partitions—in fact, so convenient that often the load-carrying capacity of the floor is seriously reduced by reason of the load being practically concentrated in the middle of spans.

A short time ago I was called upon to report on the condition of a building used for light manufacturing. The ground floor contained the machinery, and the second floor the stockroom and parts storage. The building construction was of the "combination" type; brick walls, cast-iron columns, steel girders, and wood floor-beams and flooring. The span of the girders and beams was 20 ft. The girders were 20-in., 65.4-lb. steel I-beams, while the floor beams were 6-in. by 16-in. yellow pine, spaced 5 ft. apart. Under a fiber stress of 1,200-lb. per sq. in. in the floor beams the allowable loading was 100-lb. per sq. ft. of floor area. The steel girders (with the usual 15 per cent reduction of assumed floor load) would permit a load of 180 lb. per sq. ft. Designing the floor beams for a load of 100 lb. per sq. ft., and the girders for a load of 180 lb. per sq. ft. (or the reverse), is an inconsistency which is frequently met.

The occupants of the building were concerned about its safety because of

the "springiness" of the floor. While the floor was a little overloaded in spots, there was no cause for alarm, although the owner's desire to add to the load could not, of course, be granted without arrangement.

An estimate was made of the loading imposed by the various bins and racks, and a layout of the floor drawn up. By placing the racks containing heavier materials over the girders, and building them up to the ceiling, also arranging the stocks of bins so that aisles and partitions occupied the middle of spans of floor beams, the capacity of the entire floor was more than doubled. At the same time more room was provided for trucking. The bins and racks placed over the steel girders were built solidly along the line of the columns and up to the ceiling. This construction imposed a shearing load on the column brackets and contributed little to the bending-moment on the beams.

All jobs of any importance should be laid out to scale on paper. Too frequently jobs of the kind described above are left to carpenters, simply because the job involves woodworking, and the result is often unsatisfactory because the carpenter could not give the best answers to the problems involved. All jobs must be designed somewhere. When designed on paper, changes may be made in a few minutes by the aid of eraser and pencil. When the job is designed "in the field," changes are made only at an expense in materials and labor. Probably everybody has watched the progress of "field designing." One or two men mull over the advantages and disadvantages of several ideas, and several other men stand about waiting to carry out the verdict. Generally the owners, or management, are responsible for this condition because of the erroneous idea that the trained designer is too expensive. However, when building alterations, or the proper distribution of loads is being considered, good advice is worth all, and more, than it costs.

Kansas City, Mo. C. O. SANDSTROM.

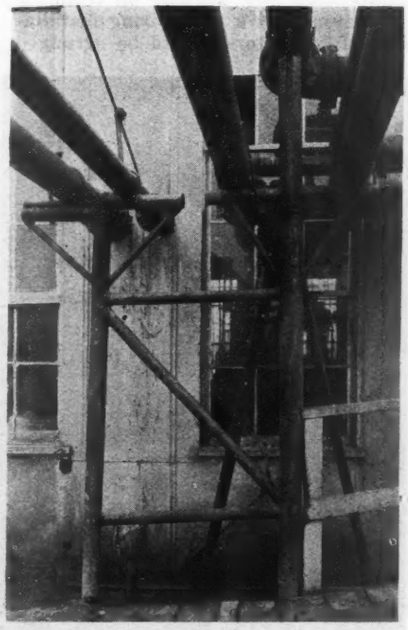
Support for Shafting and Pipe Lines Made of Welded Pipe

PRACTICALLY every concern with a welding outfit is familiar with the many welding applications possible in the miscellaneous construction work around an industrial plant. The accompanying illustrations show two such applications which may be of interest to other industrial concerns. The illustration at the left shows how a lineshaft was supported on a framework or bent built of pipe and short lengths of I-beams. Here, it was necessary to install the lineshaft at an elevation which could not be conveniently reached by shaft hangers suspended from roof trusses. These bents are rigidly supported in concrete footings.

The construction of the joint by which the top horizontal I-beams were connected to the inclined posts is given as follows in some recent literature issued by the Linde Air Products Co., New York City. First, a slot shaped like an inverted "T" was cut in the top of each post with the cutting blowpipe. This was made sufficiently wide and long enough so that the end of the I-beam could extend into the pipe. The bottom flange of the "I" rested on the bottom of the horizontal part of the slot but the top flange of the beam rested on the end of the pipe. The beam was then welded to the pipe posts at all points of contact.

These frames for supporting lineshafting and hangers were made by welding pipe to an I-beam crosspiece.

I-beams were used as top horizontals to provide a flat bearing surface for the cast-iron pillow blocks which were attached by means of U-bolts. The final lining-up was done by shimming up between each pillow block and its support. These bents were not only strong and neat but were made at a very low cost.



Another type of special support for pipe lines built up by welding scrap pipe.

The other illustration shows how a support for an irregular pipe layout was made through a special welded construction.

Making Permanent Markings for Lining Up Aisles

ALTHOUGH it is the usual custom to paint a white stripe on the floor in industrial plants to mark the location of aisles, these stripes frequently become defaced particularly on wooden floors where heavy castings and machine parts are moved around frequently. So that it will not be necessary to lay out this aisle location each time new markings are necessary, one company has nailed large metal disks to the floor along the edge of the aisle about every 10 ft. With these disks it is easy to find the line of the aisle even though it has practically been defaced by the trucking and wear of the castings. Also, the aisle can easily be lined up again by eye when painting from tack to tack.

Binder for Patching Concrete Floors Worn by Trucks

THE first step in repairing concrete floors worn into ruts from trucking is to cut away the top dressing, which is usually about 2 in. thick. A good tool for this is made as follows: Take a piece of 1½-in. hexagonal steel, about 2 ft. long, and put a diamond point chisel on one end, about 1½ in. long. This tool should be made as hard as possible and still not too brittle. With this tool and a 15-lb. hammer, the concrete top dressing can be easily broken away.

A common cold chisel proves satisfactory for trimming around the edges of the hole. Another good tool for this purpose is a mason's brick chisel. This is made of a piece of ¾-in. steel, about 6 in. long; 4 in. are used for a handle and the other 2 in. is drawn out flat, forming a blade about 2 in. long and 3½ in. wide.

All surfaces must be cleaned thoroughly and all loose material removed from the opening. Before placing the patch it is necessary to supply a binder so as to get a good union between the old and new cement. In our plant Iron-Stone Welding Cement (Stone Tar Products Company, 97 South Sixth Street, Brooklyn, N. Y.) is used. This is a white powder resembling plaster of paris and is mixed with water to the consistency of thick cream and applied with a brush. It is not necessary to dampen the old cement as the binder takes care of that. The entire surface of the old cement should be covered with the mixture and new cement poured when the binder is nearly dry.

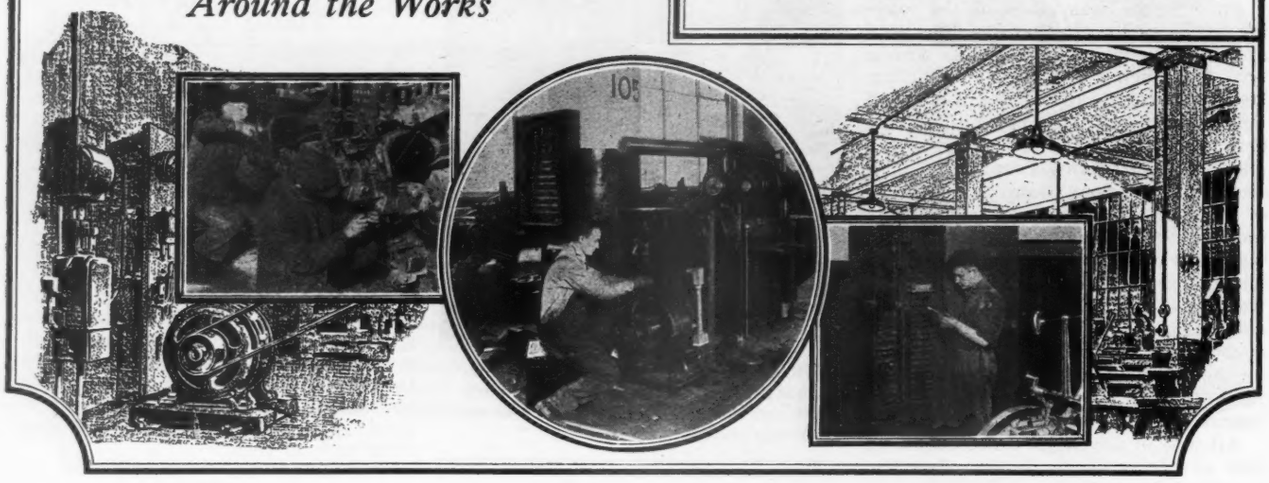
The top dressing patch is made of a mixture of one bag of cement and two wheelbarrows of sand. After the concrete patch is poured, it should be allowed to stand for about 2 hr. until it begins to dry. The surface should then be trowelled in the same manner as any cement floor.

American Chain Co., Bridgeport, Conn. D. FLIEGELMAN.

Electrical Service

Around the Works

For this section ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing or special installations.

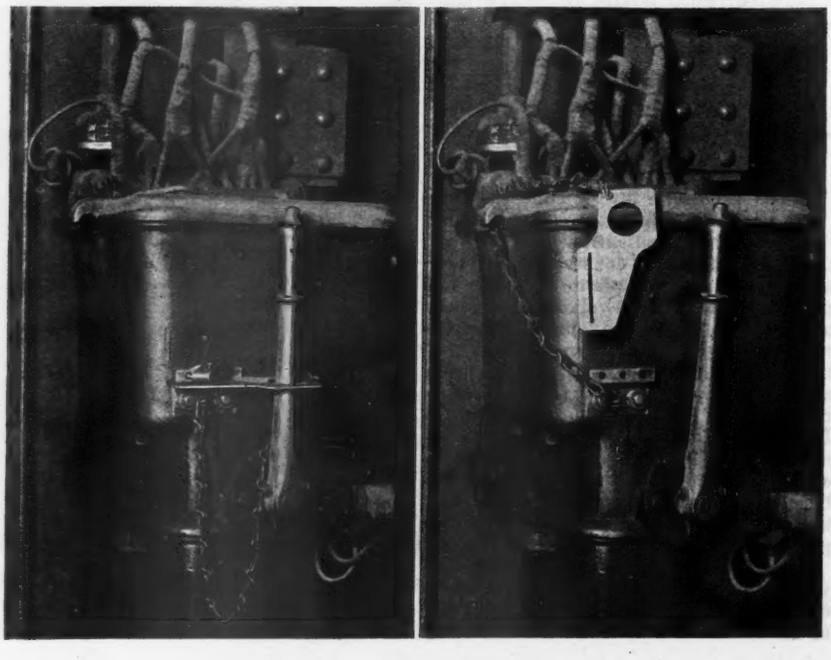


Safety Clamp for Locking Compensator to Prevent Starting of Motors

THE use of locks as a means of locking safety switches and other control devices is becoming more widespread. In the accompanying illustration is shown a method of locking the handle of a compensator in the off position, thereby preventing any one from starting the machine controlled by the compensator until the lock is removed from the clamp. Locks are provided for the operator of the machine, the electrician, and any other maintenance men, so that in case any or all of them are working on either the electric lines or any part of the machinery connected with the starter, they can safeguard themselves by locking the starter in the off position with their padlocks. Many accidents and near-accidents have been averted through the proper use and installation of this lock.

The locking clamp is made from No. 10 gage sheet steel. A hole is punched in one end of it of a size that will slip over the handle of the compensator. A slot about ¼-in. wide and 4 in. long is made in the other end to take the end of the bracket which is bolted to the compensator case. This bracket is made of No. 10 gage sheet steel and has three ½-in. holes drilled in it to permit the use of three separate padlocks. If it is likely that more than three padlocks will be used simultaneously to lock this compensator, more holes may be provided in the bracket. One end of a piece of chain is fastened to the locking clamp and the other end of the chain is fastened to the bracket cap screw. This is to prevent the clamp from being mislaid when the lock is not being used, as is shown in the right-hand illustration.

GEORGE E. WALLIS.
National Safety Council,
Chicago, Ill.



These clamps are easily made from sheet steel and will save their cost many times over in accidents averted.

These two illustrations, furnished by the National Safety Council, show how the clamp is attached to the compensator and the method of using it.

Method of Arranging Conductors to Indicate Voltage

IN HIS paper on safe operating practice with regard to electrical devices, presented at the Safety Congress recently held at Louisville, Ky., G. F. MacWilliams, electrical engineer of the Pennsylvania Coal & Coke Corporation, Cresson, Pa., spoke as follows of the necessity of having some system of identification of conductors carrying different voltages, so as to protect the maintenance men working on them.

In laying out a new wiring installation all conductors should be arranged so as to indicate to the workmen the pressures of the different wires. Colored cables and conductors, also insulators and supports, may be used to indicate the pressure of the conductors. In plants where many different circuits are laid out together, it is possible sometimes to arrange those conductors carrying the highest voltage in places where they will be safest. In some installations it may be possible to locate conductors carrying high voltages on the uppermost arm or rack of the supporting structure.

When using insulated wires it is well to use only conductors having an insulation which, under nearly all conditions, could never become dangerous. If this cannot be done, bare wires should be installed as they can in no way convey to the workmen a false idea of security. Many people have been injured by mistaking weatherproof wire for insulated wire. The

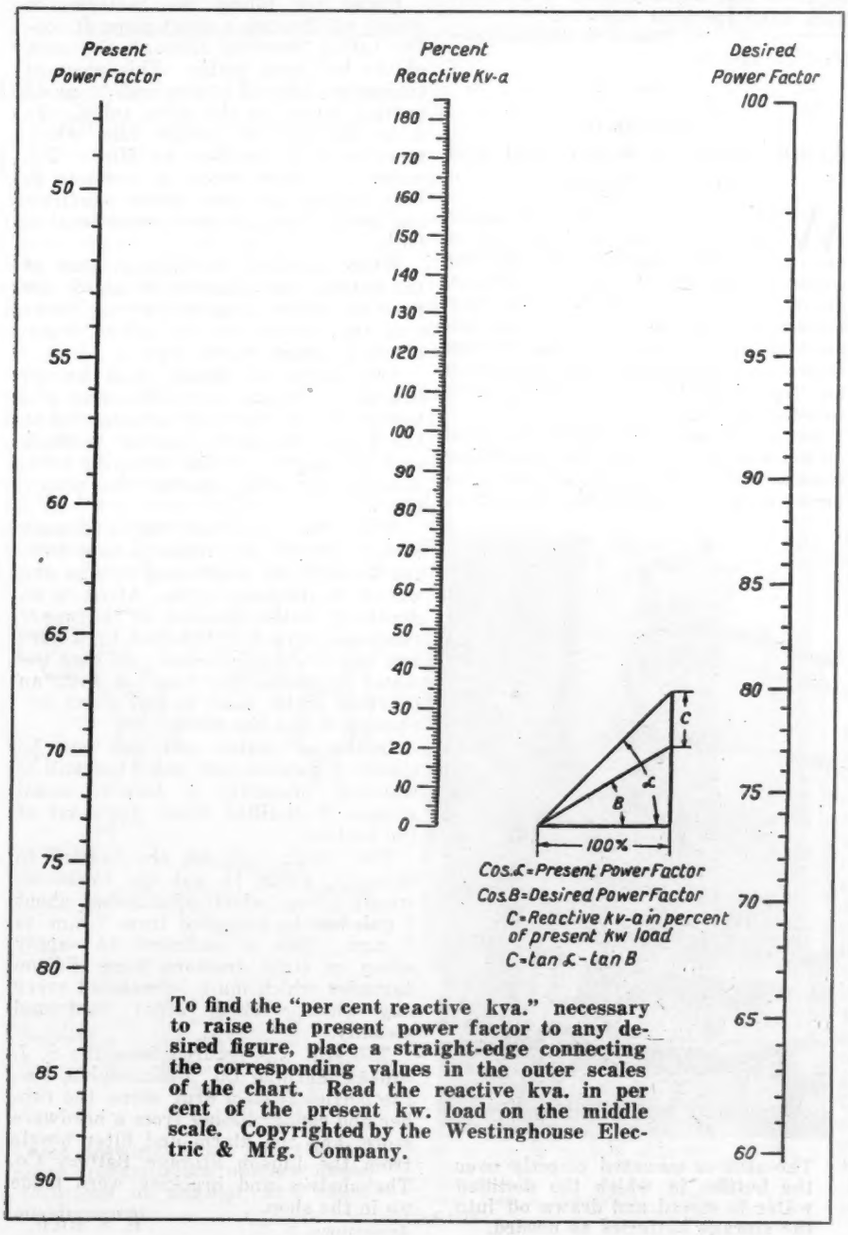
number of such accidents would have probably been much less had the wire been bare. All cable sheaths and conduits, carrying conductors, should be grounded. Metal tags may be placed on cable sheaths indicating the voltage carried by the conductors, also end bells or potheads should be plainly marked. All cables or wires should receive a test of two and one-half times their working pressure soon after being installed.

Chart for Finding Kva. Required to Raise Power Factor to Desired Value

DETERMINING the corrective kva. required to raise a certain load from one power factor to a higher power factor is a tedious process when done mathematically. The accompanying chart, which was taken from a booklet entitled "Starting Condensers for Power-Factor Correction," published by the Westinghouse Electric & Mfg. Company, performs the desired calculation almost instantly.

Assume that it is desired to determine the corrective, kilovolt-ampere capacity that is required to raise a 100-kw. load from 65 per cent power factor to 85 per cent power factor. On the left-hand scale (marked Present Power Factor) of the chart find the figure representing the present power factor, that is, 65 per cent; on the right-hand scale find the figures representing the desired power factor, which is 85 per cent. Join these two points by means of a straight edge and from the center scale read the reactive kva. in per cent of the present kilowatt load required to correct from one power factor to the other. This percentage is 55. Now multiply the kilowatt load by this percentage to get the corrective kva. required; that is, 55 per cent of 100 kw. equals 55 kva, which is the corrective capacity that will be required.

The small diagram in the chart shows how the chart was prepared. The base of the triangle is taken as 100 per cent and represents the present kilowatt load. The present power factor is represented by the cosine of the larger angle; that is, cos α and the desired power factor is represented by cos β. The reactive kva. with the present power factor is represented by the vertical side opposite the angle α and is equal to tan α. Likewise the reactive kva. of the desired power factor is represented by tan β. The reactive kva. required to raise the present power factor to the desired power factor would, therefore, be represented by the difference of the tangents of the angles and is shown at (C) in the diagram.



To find the "per cent reactive kva." necessary to raise the present power factor to any desired figure, place a straight-edge connecting the corresponding values in the outer scales of the chart. Read the reactive kva. in per cent of the present kw. load on the middle scale. Copyrighted by the Westinghouse Electric & Mfg. Company.

Method of Fishing Complex Bends Through Flexible Steel Conduit

THE method which was used to overcome the difficulty in fishing wire through flexible conduit on a special job may be of interest to readers of INDUSTRIAL ENGINEER.

A headlight turbine generator was put on one of the locomotives of a small branch line railroad and it was necessary to install lights inside and a headlight on the end of a passenger coach. The wiring was all in conduit and because of the spiral ribs in the flexible conduit it was impossible to get a fish wire around some of these bends, which were numerous and complicated, although the wire had a closed loop on the end and was twisted and maneuvered in every way for a long time.

Finally, the fish wire was taken to the shop and a No. 18 copper wire was wrapped a number of times around the loop and then tinned and soldered. After this, it was dressed down with a file until a ball about ⅜ in. in diameter was formed at the end of the fish wire. By pushing and twisting, we were eventually able to get the fish wire through the flexible conduit. It was then a comparatively simple matter to draw the conductors through also. However, the ball on the end of the fish wire really did the trick.

Oakland, Calif. S. H. SAMUELS.

Securing Maximum Service from Induction Motors

HOW to get maximum service out of induction motors is something that many users do not fully understand; nor is all apparatus for starting and protecting such motors designed to allow them to give the best performance and still protect the motor against harmful abuse. Unlike other types of motors, there is no chance of sparks being thrown from the standard squirrel cage induction motor so commonly used for all kinds of drives, until a wire or lead actually shorts or breaks, which takes some time under the severest conditions, and is preceded by considerable smoke. Overloads of short duration even to the point of stalling the motor under full-line voltage do not hurt a good standard make of induction motor if it is released in time or else cut off the line entirely, should it remain stalled, before the

winding has time to heat enough to injure the insulation. Throwing such motors on full-line voltage when standing still or even reversing them under full-line voltage does not seem to do any harm to a good machine of less than 50 hp. rating, nor to larger machines if the coils are well bound or supported. With a hand starter or compensator where the motor is disconnected when changing from the starting to the running side, as is the case with most starters, the oscillograph shows under certain conditions a higher current for one or two waves than it would show when the same motor is thrown on the full-line voltage when standing still. Such high currents have a tendency to rack the coils or twist them, but on all good, small and medium-sized machines the coils are supposed to stand such a stress.

Unlike direct-current machines a starter would not be necessary to start an induction motor or protect it from injury in starting, but it is necessary in order to make motors start smoothly, thus giving the driven machinery time to start and preventing the line voltage from dropping by allowing the motor to draw only a fraction of the current it would draw if it were thrown directly on the line when standing still.

While I would not advise anyone to abuse any motor unnecessarily thus, I am mentioning this in order to strengthen some other points that I wish to bring out in this article.

When properly cared for an induction motor will stand considerable abuse in the way of overloading. For example, an induction motor that is rated at say, 10 hp., with 25 per cent overload for two hours, will carry 10 hp. continuously with not more than 40 deg. C. rise in temperature and while so running and heated to that temperature will stand an overload of 25 per cent more for two hours before reaching a temperature 55 deg. C. above that of the room, providing that the motor is clean and the ducts open so as to afford proper ventilation. When all the ducts are filled with dirt proper ventilation is impossible and the machine may even be insulated against radiation, as is so often the case, and the user does not understand why his motor burns out and requires rewinding occasionally. Where these machines are in very dusty places they should be well cleaned with compressed air to keep the ducts open or else placed so that the dirt and dust are kept out, if the full rating is to be expected of them.

From my experience in looking after such motors in different manufacturing plants I have found that few of them have a constant load, nor is the user getting the best service out of his motors. There is oftentimes a tendency to get a larger motor than is required to carry the load. This is expensive all around. The extra power consumed in running a larger motor than necessary is quite an item when the motor is used continuously, but more than that the power factor of the line may be greatly reduced by such a practice, calling for higher rates from the power company. Where the load varies greatly or there are high peaks the starter should not release the motor for several seconds under any overloads because very often these are of such short duration that they can do the motor no harm if sufficient time is allowed for it to cool off for the next high peak. A motor so operating can without any harm carry all it will pull, which is usually over twice its rated capacity plus its momentum as it slows down in speed, if the protecting relays are properly designed. Automatic starters have a great advantage over hand-operated starters in that their protective devices can act to protect the motor under all conditions, starting as well as running, which is not true of most hand-operated starters where the handle can be held and the motor subjected to abuse in spite of the protecting devices. Also, automatic starters always give the motor the proper time in which to start and on account of the quick action of their mechanism the contacts are subjected to much less burning than is the case with hand-operated starters.

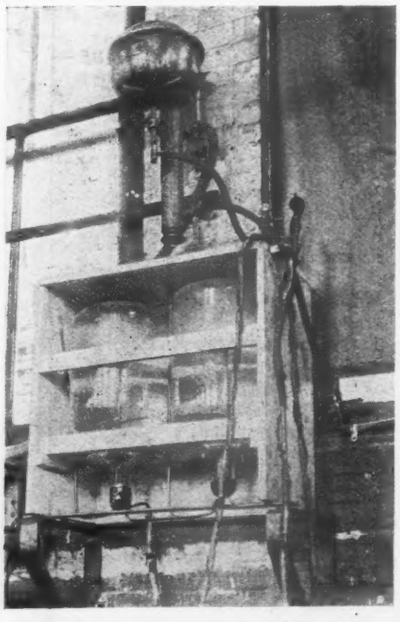
PHILIP G. BERNHOLZ.

East Orange, N. J.

Convenient Arrangement of Water Still and Storage Bottles

WHERE not over seven or eight storage battery tractors are in use, a still for supplying the distilled water needed can be put in without great expense and will be found very convenient. In one plant the arrangement of still and water storage bottles shown in the accompanying illustration has been installed and is giving very satisfactory service.

As will be seen, the still is mounted on the wall directly over the two water storage bottles which are of 5-gal. capacity each. A plank 2 in. thick, 12 in. wide and 24 in. long supports the bottles which are inverted and rest in chamfered holes. This shelf in turn is supported on ¼-in. by 1½-in. iron brackets fastened to the wall by expansion bolts. For protection, the bottles are enclosed on the ends and top by a box-like wooden frame, which has a strip nailed across the front to protect the bottles and keep them from falling in case they should tip.



The still is mounted directly over the bottles in which the distilled water is stored and drawn off into the storage batteries as needed.

Two ¼-in. copper tubes are led into each bottle through the corks, which are tied in position and covered with sealing wax. One of the tubes serves as an air vent and on the inside of the bottle reaches nearly to the top. On the outside, these tubes extend slightly above the top. The other two tubes, which project only two or three inches above the cork, are joined together by a Tee fitting, the side outlet of which is connected to another length of copper tubing which is attached to the bottom of the still and serves to convey the distilled water from the still to both bottles at the same time.

Water for filling the batteries is drawn off through a short piece of copper tubing inserted through the cork of the left-hand bottle. This piece of tubing is clamped to the wall to avoid putting strain on the other tubes. To it is attached the rubber tube which terminates in the battery filler. The water inlet tube which is common to both bottles also acts as an equalizer and maintains a constant water level in both.

When installed, the highest part of the bottles was placed 5 ft. above the floor to insure a good flow of water into the battery of the tallest truck, which is about 4½ ft. high.

The alarm is placed close by on brackets, with the dry cells, relay and bell enclosed. The leads are carried to the nozzle tip where contact is made and the alarm sounded when the solution in the cells reaches the proper height.

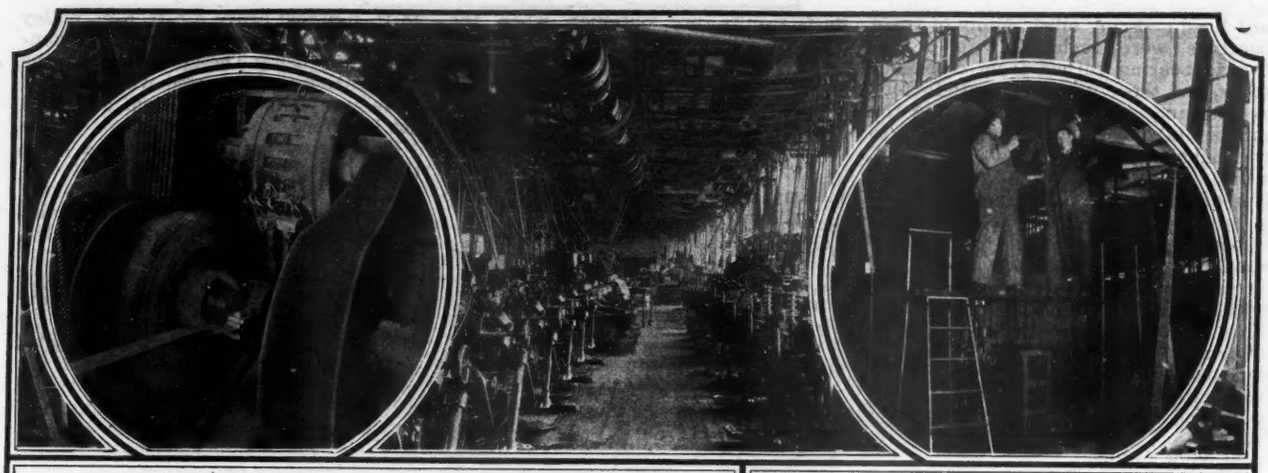
With this type of still a steady stream of cold, city water is kept flowing through the condensing column and out of the discharge pipe. About ½ in. depth of water remains in the upper receptacle where it is boiled by a bunsen burner directly below. In case the water is allowed to flow too fast, an overflow outlet leads it away and discharges it into the sewer.

Intake of water and gas can be closely regulated and when the still is working properly, a steady, small stream of distilled water flows out at the bottom.

This outfit will fill the bottles to capacity, about 10 gal., in 15 hr. of steady going, which means that about 7 gal. can be produced from 7 a.m. to 5 p.m. This is sufficient to supply seven or eight tractors using Edison batteries which must be watered every day when worked rather hard and steadily.

The still was secured from the S. J. Stokes Machine Co., Philadelphia, Pa., the bottles from a drug store, the rubber and copper tubing from a hardware store, and the alarm and filter nozzle from the Edison Storage Battery Co. The shelves and brackets were made up in the shop.

Jamestown, N. Y. H. S. RICH.



Mechanical Maintenance of

Power Drives

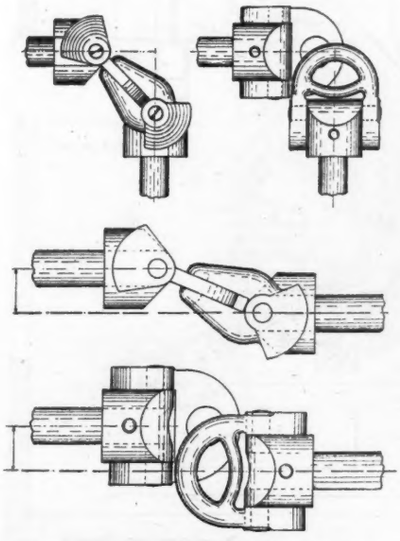
This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through transmitting equipment to all driven machines.

Driving Shafts at Right Angles With Special Transmission

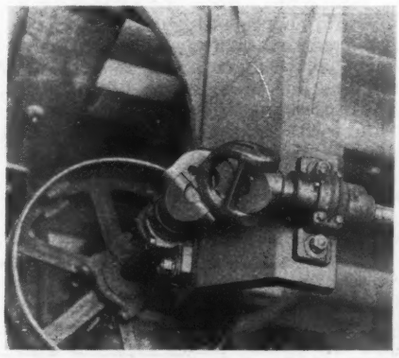
ORDINARILY where shafts must be driven at an angle, it is necessary to use bevel or miter gears, or if the connection is to be by belt, through a mule stand. Under ordinary conditions bevel or miter gears are rather noisy. In addition, it is essential that the shafts be in the same plane and not offset.

Where a 1 to 1 angular velocity ratio is desired, it is possible to use the special Bartlett angular transmission, even though the shafts be at a right angle to each other, as is shown in the accompanying illustration. When used as right-angle drives for lineshafting special hangers, with self-aligning, ball-bearing hangers and oil cases, are recommended. This drive is attached to a $1\frac{7}{16}$-in. shaft which has a full-load rating of about 3.43 hp. per 100 r.p.m. The maximum speed of this size of coupling is 465 r.p.m. This drive operates in an oil case which consists of an upper and lower half which telescope into each other. The lower half is secured to the hanger. Bearings of the self-aligning type, combined with the flexibility of an angular drive, permit the transmission to be placed directly at the shaft end even though the two shafts do not lie precisely in the same place.

How this drive operates for connecting to shafts at an angle and also in case of misalignment, is shown in the two accompanying sketches. These drives are made in nine sizes to be used on shafts varying from $\frac{7}{16}$ in. to $2\frac{1}{2}$ in. in diameter and are capable of transmitting from 0.10 hp. to 12.5 hp. The speed ratings of the smaller size are 1,850 r.p.m. maximum and on the larger size 250 r.p.m. maximum.



These drawings show how the angular transmissions operate under conditions of angular and offset misalignment.



Making a right-angle drive on a lineshaft.

Here two $1\frac{7}{16}$-in. lineshafts are connected at right angles through a special Bartlett angular transmission (G. M. Bartlett, 2533 College Ave., Indianapolis, Ind.). This special drive, together with the self-aligning bearings enable the installation to operate even though it is not in perfect alignment at the ends of the shaft. This connection will transmit up to 3.43 hp. per 100 r.p.m. and has a maximum rating of 465 r.p.m.

Lubrication Methods For Motor Bearings Operating In Hot Locations

MOTORS are sometimes called upon to operate in locations subject to high temperatures produced by such equipment as induced draft fans on boilers, calcining kilns and the like. In instances coming to the writer's attention, the oil temperature in bearings of motors in this class of service was found to be between 160 deg. and 180 deg. F. during the summer months. About thirty 25-hp. motors were operated under this condition. The air temperature on the motor floor averaged about 130 deg. F., and the motors were located about 12 ft. from the induced-draft fans and ducts which handled gases at 650 deg. F. The temperature of the motor frame was always a few degrees lower than the oil temperature and the rise above air temperature was due to the heat radiated from the surrounding 650-deg. F. bodies and by the conduction, through the frame, of the heat generated in the winding.

Particular attention was paid to ventilation of the building in order to keep as low an air temperature as possible. The motors were of 25 per cent greater capacity than required by the load in order to keep the winding temperatures within safe limits and to reduce the heat which could be conducted to the bearings. In the original installation several 900-r.p.m., 30-cycle motors were installed, but observation soon proved that the bearing wear and failures were excessive and conditions could not be improved very much with that speed of motor. In later installations standard 600-r.p.m., 25-hp. motors were used with bearing shells about 1 in. longer and $\frac{3}{8}$ in. larger in diameter than on the 900-r.p.m. motors. This, together with the lower operating speed, increased the life of the bearings to the normal figure for motors in the rest of the plant. All bearings had standard cast- or wrought-iron shells, were bab-

bitt lined and ring oiled. Many of these bearings were replaced with a full bronze bearing turned from cored bar stock, and these gave very satisfactory performance especially in reducing the number of burned-out windings due to the babbitt melting out of the shell, which allowed the rotor to rub the iron of the stator. The disadvantage of a bronze bearing lining is that when it becomes overheated and "seizes" the shaft the latter is usually scored and necessitates turning down. After a few such turnings a new shaft is required. This, however, must be balanced against the cost of a new winding when the babbitt bearing fails. When the winding is undamaged a spare rotor with end bells and bearings, may be quickly substituted in the stator after a bearing failure.

The secret of successful operation of either the bronze or babbitt type of sleeve bearing rests upon the type of oil used and the man who oils the bearing. As grades of any given oil seem to vary from year to year it would not be safe to specify any one oil as being the best and many serious "runs" of bearing failures on these drives described have been traced to a new batch of oil of the same grade, or of a new grade having the same "characteristics," according to the maker. As a rule the class of oils known as machine oils will yield a satisfactory oil after some experimenting. The viscosity does not necessarily have to be high but rather should be as uniform as possible over a wide range of temperature. It should have the body and tenacity to cling to the ring in good quantity up to an oil temperature of 180 deg. F. Some oils become as thin in consistency as kerosene at this temperature and the bearing will run dry with a full oil well. A thick oil of the "cylinder oil" class is too heavy when the motor has been shut down some time and the oil allowed to cool. Then, the ring will hardly turn when the motor is started up and a burned out bearing often results; this may be overcome in a degree by mixing the "cylinder" and "dynamo" classes of oils to the proper consistency so that the oil ring will revolve freely when the mixture is at the air temperature of the motor room. This method depends on the personal element entirely too much and it is always better to search for the proper oil which will work under a fairly wide temperature range and so eliminate one more variable or source of error which may cause trouble.

As mentioned before much depends on making a careful selection of the proper type of man for oiler. A settled, middle-aged man who is conscientious should be selected and the wage proportioned to the importance of the job. A young man who is energetic and restless is not the type of man for a particular oiling job which is a monotonous routine of watchful waiting to detect the first sign of overheating. Where dust and heat are both present the bearings should be oiled and inspected twice each day. Where the temperature is so high a bearing which is "overheated," relatively speaking, may be detected by the quantity of oil necessary to replace the evaporation. Best results are obtained when the bearing is flushed and oil replaced with new oil once a week.

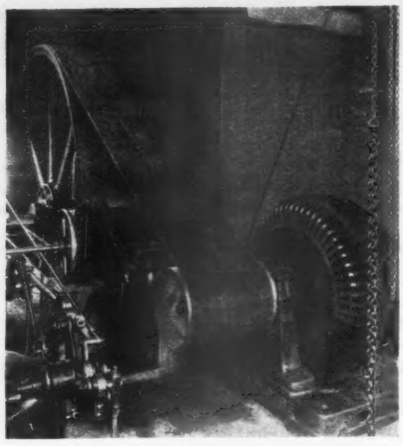
J. ELMER HOUSLEY.
Electrical Engineer,
Aluminum Company of America,
Alcoa, Tenn.

Changing Group-Drive Plant to Individual Drive

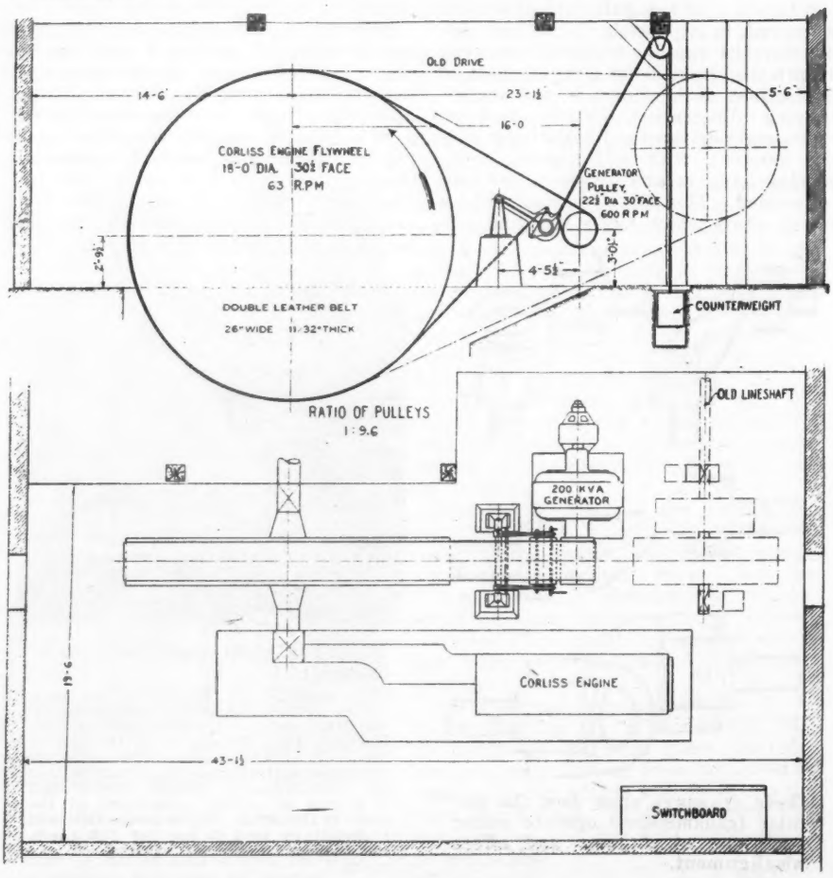
OPERATING men in plants with an engine-driven lineshaft may be interested in the following account of how a similar installation was transformed to electric drive without interruption to normal operation. Here an 18-ft. flywheel drove a 6-ft. 6-in. pulley on the lineshaft through a 26-in. double leather belt. The generator and the Lenix drive were erected while the old drive was still in operation, as it did not interfere.

On the first Saturday afternoon after they were installed, the old belt was cut, spliced and fitted to the 200-kva. generator, shown in the sketch and also in the accompanying illustration. The entire new system was tried out on Sunday morning for a few hours to see that it operated satisfactorily. In the meantime, the lineshaft had been divided into sections that were connected up to electric motors; some of the machines were provided with individual drive so that on Monday morning, the entire plant operated with a mixture of group and individual drives, with no interruption of production.

The pulley ratios at the engine flywheel and at the generator are 1 to 9.6 and operate on 16-ft. centers. This permits the generator to operate at 600 r. p. m. whereas if it were not possible to get such a high pulley ratio, a low-speed generator would have to be used which would have cost considerably more. When the equipment is idle over night and on Sunday, the counterweight which gives the increased arc and maintains the tension is raised so as to relieve the belt tension and accordingly lengthen its life.

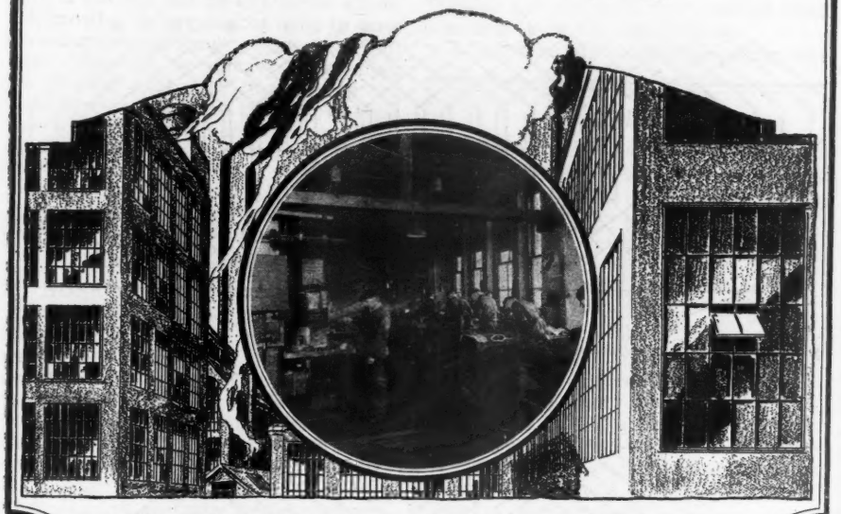


This shows the compact arrangement of the drive for an engine-driven generator shown in the accompanying sketch.



This sketch shows how the generator was placed in line with an engine drive so that the equipment of the plant could be motor driven instead of operated from an engine-driven lineshaft.

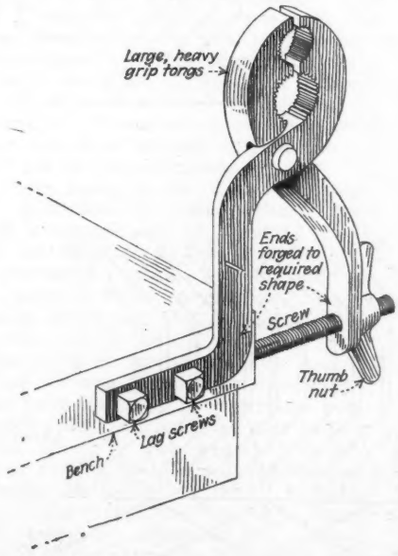
In the Repair Shop



This section is devoted to repair work, large and small. Special attention is given to shop or bench tools and short cuts or improved methods. Contributions are always welcome.

Easily-Made Grip Tongs Used as Vise for Holding Small Work

A SIMPLE and easily-fashioned but very serviceable tool was made from a pair of grip tongs and is in daily use at one repair shop. As will be seen from the illustration, one handle of a large pair of heavy tongs was forged flat and bent at a right angle so that the tongs could be fastened to the side or end of the bench with two lag bolts. The other handle of the tongs was slotted to permit passage of a long screw, one end of which is screwed into a small plate which is firmly fastened to the edge of the bench. The end which passes through the handle of the tongs is fitted with a thumbnut so that the tongs can be firmly closed like a vise around any desired object.



The tongs are mounted on the bench and fitted with a long screw and thumbnut for closing them tightly around pipe or other work.

The variety of work which this fixture will handle is very wide, as it can be used for holding pipe, round bar, pieces which are being filed, drilled or cut with a handsaw, and so on. It has also been found very useful for gripping cable or rope while splicing. Altogether, this simple tool replaces or is the equivalent of a vise, at a considerably less cost.

Washington, D. C. G. A. LUERS.

How to Test Lap-Wound Armatures with Equalizer Connections

REPAIRMEN are sometimes in doubt as to the proper procedure when testing lap-wound armatures with equalizer or cross connections. However, if the principle of the equalizer connection is clearly understood, the problem is quite simple. The fundamental principle is that points on the armature that are of the same potential and polarity are connected together. On a four-pole machine these points will be 180 deg. apart, on a six-pole, 120 deg., on an eight-pole, 90 deg., on a ten-pole, 72 deg., and so on. There are a number of ways of putting the equalizer connections on. In one method rings are used either behind the commutator or at the rear of the armature winding. Another method makes use of the two-layer, one-turn open-end coil, either diamond or involute type of winding.

The minimum number of rings is equal to one-half the number of poles, and each ring must have P ÷ 2 connections or taps to it, where (P) equals the number of poles.

Then for a four-pole machine the minimum number of rings would be two and each ring would have two taps or connections to it. The connections on ring (1) would be 180 deg. apart or on the half; the connections to ring (2) would also be 180 deg. apart, but the spacing between the taps to rings (1) and (2) would be 90 deg. Assume a four-pole armature having twenty-four slots and bars and two equalizer rings. The pitch between taps on each ring would be $24 \div 2 = 12$, or bars (1) and (13), and the spacing between taps to rings (1) and (2) would be $24 \div 4 = 6$ or bar (7); the second tap to ring (2) would be bar (7) plus 12 equals (19).

The above brings us to the rule that governs ring-type equalizers: The number of rings (R) times the number of pairs of poles (S) must be a multiple of the total number of single coils (C). The total number of single coils is equal to the number of slots times the coils per cell. In the above, the expression "number of pairs of poles," is also equal to the number of taps required per ring; then the total number of taps (T) to all rings equals R × S, and the spacing in single coils or bars between taps is C ÷ T. In many cases the number of rings must be selected to satisfy the above formula. For example, assume a fourteen-pole armature having 280 slots and 840 bars and single coils, three coils per cell. Now the minimum number of rings is $14 \div 2 = 7$, and the number of taps per ring is also 7 and the total taps would be $7 \times 7 = 49$. But $840 \div 49$ will not give even spacing. The multiples of 840 are 420, 280, 210, 168, 140, 120, 105, 84, 70, 60; then the least number of rings would be ten and with seven taps per ring, the total taps would be $7 \times 10 = 70$, and the spacing would be $840 \div 70 = 12$, or (1) and (13). The spacing on each ring would be $840 \div 7 = 120$, or bars (1), (121), (241), (361), (481), (601) and (721) would connect to ring (1). Then the connections to ring (2) would start at bar (13), the other bars would be (133), (253), (373), (493), (613), (733). Ring (3) would start on bar (25); ring (4) at (37); (5) at (49); (6) at (61); (7) at (73); (8) at (85); (9) at (97); and (10) at (109).

Per cent equalization equals (T ÷ C) × 100, or in the above case (70 ÷ 840) × 100 = 8⅓ per cent equalized.

The above will enable anyone to figure out the spacing of ring-type equalizers, which is important to know when testing, as will be shown later.

With the coil type of equalizer, the pitch between points will be C ÷ S as before and the spacing will be C ÷ E where (E) equals the total number of equalizers. The number of rings, taps or equalizers can easily be counted. If the connections are made at the back of the commutator, examine each commutator riser between the commutator bar surface and the bottom armature coil lead and a place will be found where the equalizer connections are soldered to the riser. When coil-type connections are used there will be a bottom and a top connection to each point except on four-pole machines. Thus the coil type of connection forms a ring, connecting the equipotential points together.

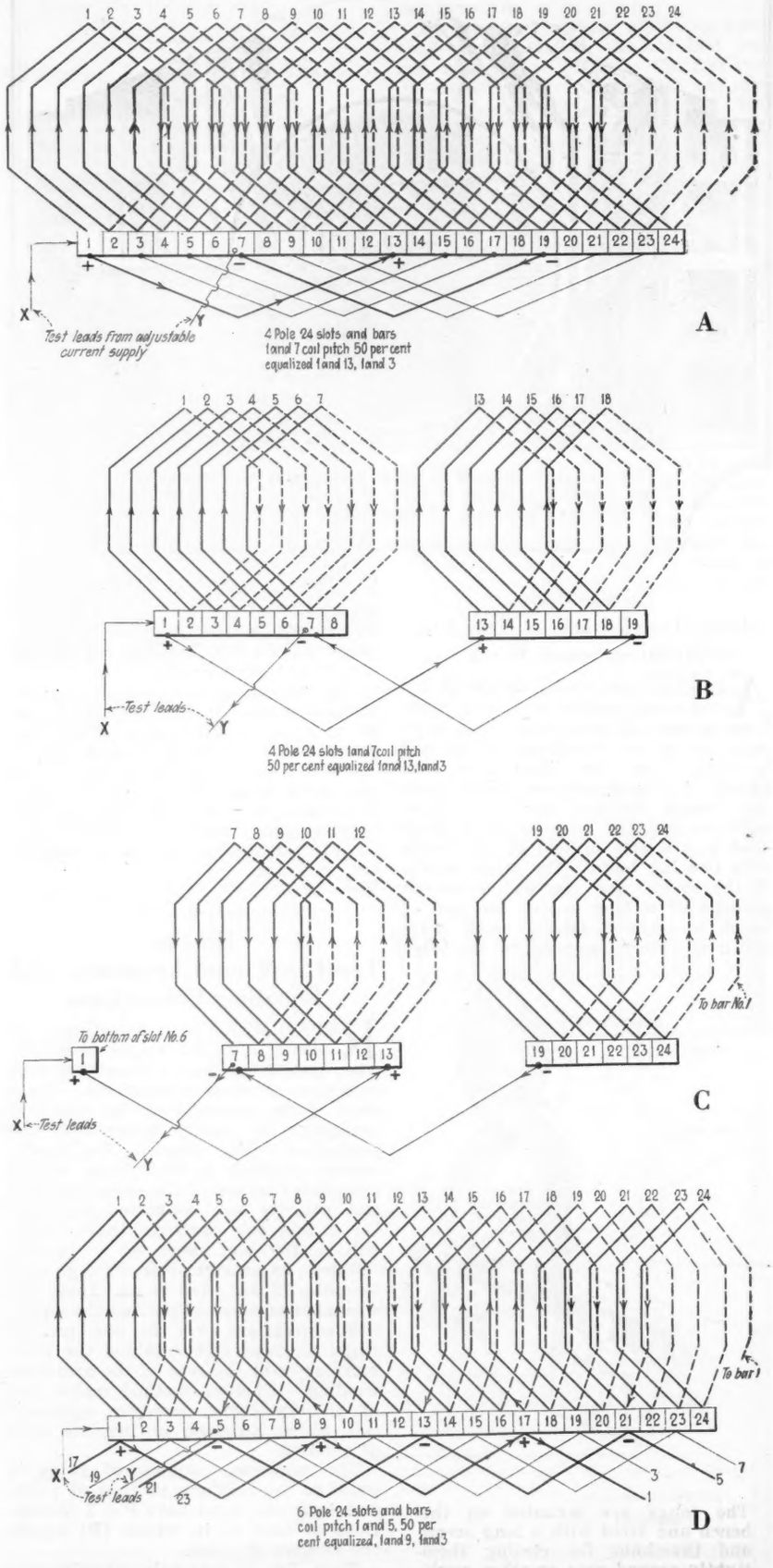
Now we can consider the testing of the complete armature using the bar-to-bar millivoltmeter test. The first step is to find the tap pitch C ÷ S and divide this by 2, or (C ÷ S) ÷ 2. Then place one of the adjustable, test current supply leads to bar (1) and the second test lead to the bar one-half the tap pitch away; this will supply current to all brush positions and the effect will be the same as if the armature were in the field and held from turning while current was supplied to the brushes. The current will follow its regular paths.

For example, take the case shown in (A) of the diagram. The tap pitch is 1-and-13, and half pitch is 6, or 1-and-7. Then if we place one current supply lead on bar (1) and call this a positive (ingoing) lead and the other or negative lead on bar (7) we will also supply current to bar (13) through the equalizer connection, and bar (13) will be positive. Likewise bar (19) will be negative, as it is connected to bar (7) by the equalizer. We can adjust the current so as to get a good scale reading when the meter is put across bars (1) and (2). The whole armature can be tested without removing the leads from bars (1) and (7), but when the meter leads are put on bars (7) and (8), we will get a reversed reading. This reading will be reversed until the leads are placed on bars (13) and (14); then it will return to normal and will read normal until bars (19) and (20) are reached, when the reverse reading will again be obtained. All positive readings can be obtained by putting the positive supply lead on bar (7) and the negative lead on bar (13), one half-pitch away.

Move the leads in this manner each time, being careful of the spacing. In diagram (B) are shown two of the paths through the windings with the supply leads on bars (1) and (7). The current flows from left to right, or through coils (1), (2), (3), (4), (5), (6), and coils (13), (14), (15), (16), (17), (18). Diagram (C) shows the other two paths from bars (13) and (1) right to left, or through coils (12), (11), (10), (9), (8), (7), and coils (24), (23), (22), (21), (20), (19). This explains why reversed readings are obtained on the meter.

Diagram (D) shows a six-pole armature with coil-type equalizers. Note that three connections form a closed circuit or ring, connecting together three equally-spaced points.

Then to test lap-wound armatures with equalizers of any type, determine the tap spacing, locate one bar to which an equalizer connection is made, put one test current supply lead on this bar and the other test lead on a bar one-half of a tap pitch away on either side of the positive test lead. For example, in diagram (D) use bar (9) for the positive and bars (5) or (13) for the negative lead. Then apply the millivoltmeter leads between these points, that is, to bars (1) and (2), (2) and (3), (3) and (4), (4) and (5). Then shift test lead (X) in diagram (D) to bar (5) and lead (Y) to bar (9), and test with the meter bars (5) and (6), (6) and (7), (7) and (8), (8) and (9). As before shift (X) to bar (9), (Y) to bar (13), and so on. Be sure to start on a bar that has an equalizer connection attached to it, and space the leads one-half of a tap pitch; also be careful


Test leads from adjustable current supply
4 Pole 24 slots and bars 1 and 7 coil pitch 50 per cent equalized 1 and 13, 1 and 3
A
Test leads
4 Pole 24 slots 1 and 7 coil pitch 50 per cent equalized 1 and 13, 1 and 3
B
To bottom of slot No. 6
To bar No. 1
Test leads
C
To bar 1
Test leads
6 Pole 24 slots and bars coil pitch 1 and 5, 50 per cent equalized, 1 and 9, 1 and 3
D

Current paths through and method of testing lap-wound armatures with equalizer connections.

to maintain this spacing throughout the test and do not interchange the test leads. This method gives consistent results if carried out as explained above.

A growler or bug can be used to good advantage in testing equalized windings. There is no danger of burning out shorted coils with the bug, as the closed circuit is formed through at least four coils on a 50 per cent equalized armature.

Pittsburgh, Pa. A. C. Roe.

Time Saving Method of Seating Carbon Brushes

THOSE who are familiar with the operation and maintenance of commutating machines well know the particularly unpleasant drudgery of "grinding in" a set of direct-current brushes by hand. The job is very tedious and takes considerable time. Brushes installed with flat faces, as received from the manufacturer, and not "sanded in" will require from four to five days to as many weeks with the machine operating at reduced load, to seat themselves properly. The length of time required depends primarily on the composition of the brush and the condition of the commutator.

A quick method of obtaining even better results than can be secured by grinding the brushes in with sand paper by hand is to coat a portion of the commutator with shellac and sprinkle very fine sand over the shellacked portion before it is dry. After the shellac has dried, a few minutes run of the motor or generator, as the case may be, will grind the brushes to a very good seat. The sand and shellac can then be removed by washing with alcohol.

Oakmont, Pa. A. W. McAuly.

How to Determine Proper Length of Wrench for Use on Nuts

HOW often does it happen in tightening up nuts on some machines that the threads on the nuts or bolts are stripped? In tightening nuts, a pipe should never be slipped over the end of the wrench in order to increase the leverage. Wrenches should be selected that are short enough so that the nut will not be over-strained.

Tests made by the Crane Company, as published in *Valve World*, show that a compression of about 12,000 lb. can be obtained by one man using a 16-in. wrench on ¾- to 1-in. bolts, or by using a 36-in. wrench on 1⅛- to 1⅜-in. bolts, or by using a 60-in. wrench on 1½- to 1¾-in. bolts, or by using a 72-in. wrench on 1⅞- to 2-in. bolts. It was found that square nuts give from 20 to 25 per cent less compression than do hexagon nuts with a given effort on the wrench. Rough-cut or uneven threads will reduce compression 10 to 15 per cent. Lubrication of the thread and bearing surfaces will increase compression approximately 50 per cent over that which may be obtained with dry threads.

It is not necessary to over-strain bolts if proper wrenches are used, and if the correct length of wrench is employed it will be found almost impossible to over-strain bolts larger than 1 in. in diameter. The overall lengths of wrench given in the table are recommended for use with the sizes of bolts also shown in the table below.

A good rule for approximating the correct length of wrench is to multiply the bore of the nut, or the diameter of the bolt, by 15. The result obtained is the length of the wrench in inches. For example, a 1-in. bolt would require a 15-in. wrench and a 2-in. bolt would require a 30-in. wrench.

Length of Wrench for Different Sizes of Bolts

Size of Bolt, Inches	Length of Wrench, Inches	Size of Bolt, Inches	Length of Wrench, Inches
½	7½	1¼	19
⅝	9⅜	1½	23
¾	11½	1¾	27
⅞	13¼	2	30½
1	15	2¼	34

Circuit Breakers for A. C. Motors

(*Continued from page 579*)

In one very important installation of this class, each three-wire lighting feeder is protected by a three-pole, three-coil breaker, equipped with shunt tripping coil. The compensators, of which there are two, intended to be operated either separately or in parallel, are each protected by a pair of double-pole, overload and no-voltage circuit breakers. One of these circuit breakers is connected in the positive lead and equalizer main of the compensator; the other breaker is similarly connected into the negative side of the compensator, and the two instruments are so interlocked that the opening of one causes the opening of the other, although they may be closed independently. Auxiliary circuit-closing devices are provided which bring into circuit the shunt tripping coils of the feeder circuit breakers when the compensator circuit breakers are opened. Thus should the compensator be out of service, the lighting feeders will be automatically disconnected.

Where overload circuit breakers are employed for the protection of compensators they should be equipped with direct-acting time-limit features. They then afford protection against short circuits and unduly sustained overloads, but being insensitive to slight overloads of momentary duration do not cause unnecessary service interruptions.

Maintenance and Operating Costs

(*Continued from page 570*)

The location of the various units which co-operate in the manufacture of roofing has an important bearing on the occasional production and handling of this commodity. Rag collecting depots and the felt mills are, accordingly, located where abundant water and labor are obtainable, at suitable shipping points near the sources of rag supply, particularly in the eastern central states. The price of rags varies considerably throughout the year; so large rag storage adjacent to felt mills is essential in the successful conduct of this business. It seems best to locate saturating, coating and shingle plants more with relation to the distributed market, at various good shipping and labor points throughout the country. Roofing felt can be shipped in rolls, protected against the absorption of moisture. Roofing asphalt can also be shipped readily in tank cars provided with coils for steam heating when unloading in cold weather.

The oil refinery is located in the main channels of transportation from Mexico and the Southwest to the market center in the central states, so as to distribute asphalt to the saturating and coating plants and at the same time be able to distribute competitively to other markets by-products which are not used in the roofing industry. Owing to fluctuations in the price of oil throughout the year, and to insure continuous operation, considerable storage capacity for crude at the refinery is essential. Storage for roofing asphalt is best provided at the saturating plants.

Owing to the differing and varying requirements of the markets supplied by individual roofing plants, and the economy of performing the granulating operation on as large a scale as possible, the slate granulating plants are best located at the quarries or mines. By this arrangement it is comparatively simple to carry the rock from the ground through the granulating plant into box cars and deliver it to protected bins at the coating plant without allowing it to become exposed to moisture.

The quantity of ground mica or talc used in the industry, for coating varieties of smooth surface roofing, is small and easily obtained.

Testing Wiring of Transformers

(*Continued from page 565*)

the secondaries of each transformer in one bank.

In paralleling three-phase transformers, it is necessary to observe the phase rotation of the primary and secondary as well as polarity, impedance, and voltage ratio.

Method of Testing Three-Phase Transformer Connections

To determine whether two three-phase transformers are properly connected for parallel operation, connect the high-tension sides of both transformers to the power supply after having connected the low-tension side of one to the low-tension bus as shown in Fig. 15. Then connect one low-tension lead of the second transformer to the bus. With a voltmeter measure the voltage across *M* and *N* and across *O* and *P*. If there is zero voltage across these pairs of leads the polarities of the two transformers are alike and the transformers may be paralleled. If the voltages across the two pairs of leads are double the rated secondary voltage then the polarity of one phase winding is reversed with respect to the other. The remedy is to reverse the polarity of one transformer by changing the internal connections.

If the voltage across one pair of leads is zero and is twice rated voltage across the other, the polarity of the transformers is correct, but the terminals are in different order. The remedy is to interchange *M* and *O* so that *M* and *P* will make one bus connection and *O* and *N* the other. The voltage should be measured across the new pairs of leads to be sure that it is zero before the connections are made.

If one voltmeter reads zero and the other reads 1.73 times the secondary voltage, we have a case of reversed polarity and transposition of terminals combined. The remedy in this case will be to change the internal connections of the transformer.

An example of transposition of leads on a three-phase transformer is shown in Figs. 16 and 17. The nameplate gave a connection diagram as shown in Fig. 16 and its vector diagram is shown below the connection diagram. The transformer was tested by using single-phase low voltage on the high-tension leads *A* and *B* (which excite the center winding of the transformer). The maximum secondary voltage observed was from *A'* to neutral, which proved that the *AB* winding and the *A'* low-tension winding were on the same leg of the core as shown in Fig. 17. The other two windings in Fig. 16 were checked similarly.

Thus it was found that the transformer secondary leads had been crossed inside the case so that the phase rotation of one transformer did not conform to the other one. It should be noted that the voltages of the low-tension *B'* windings in the two transformers are 120 deg. to each other. The same is true of the *C'* windings. If the secondaries were to be paralleled, a serious short circuit would occur.

Shelves and Racks in Storerooms

(*Continued from page 573*)

a small shelf, or ledge, of convenient height for working on; several of these are shown in accompanying illustrations. When units are assembled "double-face" or "back to back," one back may be made to serve both units.

Shelves may be turned into bins by adding "bin fronts" which are generally made in the same height as the vertical adjustment, 2 or 3 in., or in multiples of it. In addition, some provision is generally made on the front for attaching cards or other identifying means to show what is in the bin.

Where dust may injure the materials stored, or where it is desired to keep them under lock and key instead of in open storage, although the storeroom may be enclosed, either sliding or swinging doors may be attached to most kinds of shelving. How this is done is shown in some of the accompanying illustrations. In other cases where dust only is to be kept out, drawers or boxes are used in the storage space. These are usually made so that they fit rather closely but not too tightly at the top, so that they exclude most of the dust. These boxes may be made with several compartments and so used to store a number of different supplies which are kept in small quantities, thus adding to the total capacity of the storage space. For example, a 4-in.x6-in.x18-in. box may have several compartments, each holding a different stock part. For the smaller boxes these compartments are frequently made with wooden front and back and metal sides and bottom. This reduces the wood used to a minimum and, at the same time, gives the thin sides which are one of the big advantages of steel boxes over wooden boxes for shelf storage.

Open steel shelving differs from closed steel shelves in more than merely being without a back. In the closed type of steel shelving the back and side pieces help to support and strengthen the construction. In the open type of steel shelves, these are lacking and the shelves are attached directly to the steel framwork. This gives a construction with advantages both as to light and as to the proper selection from the pile and when placing material on the shelf. Open shelves are generally used for storing tools, punches, dies and similar material where it is of irregular shape and there is no particular reason for keeping one part or item separate from the others, as there is in the case of many manufactured or supply parts which may be similar to others.

In selecting either open or closed shelving, care must be taken to see that it is strong enough for the loads it is called upon to sustain. Also, it is always well to bear in mind that shelves should be made strong enough to sustain practically any loading which may be put upon them in the shop. Frequently shelves which are called upon originally to bear light loads may, under a change of conditions or product, be either moved or required to sustain a much heavier load. When there is a question as to whether the shelving will stand up under the new conditions the decision generally is to "try it out." Steel which has been "sprung" by overloading, however, does not have the power to withstand or carry the load which it did before. In this way, it is always well to consider future possibilities.

In planning for shelf storage, it is necessary to take into consideration the following factors: (1) The dimensions of the room to be devoted to storage; the height of the ceiling, location of pillars, posts or other obstructions, size of doors and windows and location of any permanent room fixtures. (2) The nature of the material to be stored; that is, whether it is light or heavy, bulky or compact, small units or large, whether it is loose or in packages. (3) Is

it necessary to make provision for card indexing the contents of each bin? (4) What load per square foot of shelf is to be carried? What is the permissible loading per square foot of floor space? (5) What size unit of shelf could be adopted as standard, or would a wide variety of sizes or spaces be necessary?

In considering any installation, it is well to bear in mind a few things concerning shelving. First, every type of equipment has its limitations. Steel has a definite strength according to its gage and bracings, and if it is overloaded far in excess of what it is supposed to carry, excessive and perhaps damaging strains may be set up in the steel work. If heavy loads are to be carried, it is usually possible to make narrower or reinforced shelves.

The manufacturer of the shelving gives complete directions for its erection. Incidentally, most of the better grades of shelving will go together easily if the directions for erection are followed. In some of the cheaper types more difficulty is involved in their erection. Outside of that, there are two points which need to be kept in mind. The first of these is that if the floor is not level care should be exercised to see that the partition or framework is blocked up so that the whole unit is sitting firmly on the floor without any twisting or causing other unusual strain. The unit could be strained much more severely by being erected on uneven flooring than it would ordinarily be through the weight of the material contained in it. The other point to remember is that all bolts should be made tight. Loose bolts will permit sections to bulge or give and throw unnecessary stresses into the steel work. Another unnecessary strain is often caused by men carelessly climbing up shelves midway between supports.

Ease in erecting and dismantling are always points to be considered. While a stock room is generally considered to be a permanent institution, conditions change so much in industrial plants that this is seldom true. When changes must be made the ease with which this can be done is important.

EDITOR'S NOTE: Acknowledgment is made to the following companies for assistance in furnishing information and photographs for this article: The Berger Mfg. Co., Canton, Ohio; Hadden Bin Label Co., Hadden Heights, N. J.; The E. F. Hauserman Co., Cleveland, Ohio; Lyon Metallic Mfg. Co., Aurora, Ill.; The Mills Co., Cleveland, Ohio; The Van Dorn Iron Works, Cleveland, Ohio.

Practical Books

For Your Personal Library

Every man who aspires to larger responsibilities should build up a professional library. Copies of these books may be obtained from the publishers mentioned.

Principles of Business Writing—By T. H. Bailey Whipple, literary critic. Westinghouse Electric & Mfg. Co. Published by Westinghouse Technical Night School Press, East Pittsburgh, Pa., 182 pages, price $2.

This book takes up three subjects which should be of interest to every technical or industrial man. These are: letter writing, report writing, and words and phrases often misused. As much of a man's success in the better jobs depends upon his ability to express himself and present his ideas in writing to those above him, a book of this type should be very valuable to industrial men, as well as to those who are engaged regularly in the preparation of business letters and reports and desire to become more proficient in this work.

* * * *

Arc Welding Handbook—By C. J. Holslag, chief engineer, Electric Arc Cutting and Welding Co. Published by McGraw-Hill Book Co., 370 Seventh Avenue, New York, N. Y. First edition, 243 pages, illustrated, $2.

This book, which is of handy, pocket size, was written to serve as a simple and practical manual of instruction in arc welding for both operators and supervisors, as well as a reference guide for all who are concerned in any way with the use of arc welding.

The preliminary preparation of the work and the methods employed in making all types of welds are described clearly and in sufficient detail to meet the needs of the beginner—while the experienced operator will find much that may be new to him. A list of questions has been appended to each chapter for the purpose of helping the student or reader obtain a more thorough grasp of the principles explained.

* * * *

Truscon Maintenance Data Book—Compiled and published by The Truscon Laboratories, Detroit, Michigan, 100 pages, illustrated. Price $3.

If you want to know how to waterproof the basement, daylight the interior of the factory, protect the roof against leakage, harden the concrete floors, clean windows of rust, enamel shower bathrooms, paint concrete, give steel an acid protective coating, or varnish or waterproof canvas, you will find full information with recommendations on how to take care of any of these conditions in this book. All information is compiled strictly from the maintenance point of view and is fully illustrated with maintenance charts, color charts and photographs.

In this book maintenance is classified under the following headings: Exterior, interior, floor, basement and roof. With this classification and the cross index practically everything in regard to any section of a building can be conveniently referred to. Another feature of special interest in this book is the eight pages of useful information, covering everything from weights and measures to mensuration formulas. Because of its completeness and the cost of producing it, the book is not issued for general free distribution.

* * * *

Management's Handbook — Edited by L. P. Alford, Editor of *Management and Administration*. Published by the Ronald Press Co., 20 Vesey St., New York, N. Y., 1,607 pages, 630 illustrations, 290 tables, flexible binding. Price $7.50.

In this first handbook on management subjects the editor was assisted by thirty-four others, each an authority in his subject. The information is well selected, inclusive and carefully arranged and a complete index makes it readily accessible. It should be very helpful to anyone holding a responsible position in industry or business.

There are thirty-two sections in the handbook as follows: Tables and statistics, mathematics, charts, management ratios, the industrial plant, plant layout, office management, forms, classification and symbols, purchasing and storeskeeping, tool storage and issue, production control, control of quality, material handling, operation study and rate-setting, wage payment and timekeeping, simplification and standardization, plant maintenance, conserving and salvaging materials, packing for shipment, traffic and shipping, economic principles, organization for ownership, organization for operation, budgetary control, cost accounting, cost and profit variation formulas, banking relations, insurance, market analysis, labor maintenance, information filing system.

* * * *

Electric Elevator Equipment for Modern Buildings—By Ronald Grierson, associate member of the Institution of Electrical Engineers and of the Institution of Mechanical Engineers. Published by D. Van Nostrand Company, 8 Warren Street, New York City, 173 pages, illustrated. Price $5.

The object of this work is to present to engineers, architects and others interested in the subject, a practical guide for the selection, installation, operation and maintenance of modern electric, passenger, freight and service elevators and escalators. A feature of this volume is the attention paid to the problems of selecting an elevator of the proper type and capacity.

One chapter is devoted entirely to specifications. An appendix gives a checking list which contains practically every possibility or condition which might come up in the installation.

Other sections of the appendix are devoted to elevator accidents, regulations relating to the installation, operation and maintenance, inspection form and test sheet. This volume is based on both English and American practice.

Trade Literature
You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Electric Light and Reflector Cleaner Company, Appleton, Wis.—A folder describes a special device with which lamps and reflectors can be cleaned from the floor without removing them or using a ladder.

The Truscon Laboratories, Detroit, Mich.—The "Truscon Maintenance Map" presents in simple, easily understandable form a maintenance guide for buildings and equipment. It shows a cut-away view of the building, in colors, and points out by arrows and descriptive text the proper paint or protecting coat to use for floors, walls, machinery, pipe lines and other surfaces. In addition, a concise table gives a large amount of useful information regarding the quantities of these materials required.

The Texas Company, 17 Battery Place, New York, N. Y.—The October issue of "Lubrication," issued by this company is devoted to a discussion of lubrication in the paper industry. The information presented is also given in tabular form for quick reference.

Century Electric Company, St. Louis, Mo.—A folder entitled "Bearing and Oil Well Construction" gives a complete description and discussion of the advantages claimed for this equipment in Century polyphase motors.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—Publication S. P. 1666 entitled "Silent Sentinels" is a 72-page booklet on protective relays for alternating and direct-current systems. This contains the results of many years of experience in the manufacture and study of relays by the Westinghouse Company and over 140 illustrations, including schematic, vector and wiring diagrams to supplement the description of the theory and practice of relay operation.

Square D Company, Detroit, Mich.—Announcement is made of a new type of voltage tester which does not require the use of lamps. This will also indicate whether the current is alternating or direct and will indicate the voltage up to 600 volts. It is easy to carry and claimed to be simple to operate and to replace lamps in locating open circuits, blown fuses and motors running single phase.

Economy Fuse and Manufacturing Company, Greenview Avenue and Diversey Parkway, Chicago, Ill.—A folder describes the various ferrule and knife blade type fuses and the removable plug as well as giving prices.

General Electric Company, Schenectady, N. Y.—Circular 67,640.2, Class 15, describes the induction over-current time relay with circuit-closing contacts, controlling one circuit. These are made in different types for slightly different application.

The Van Dorn Electric Tool Company, Cleveland, Ohio—A 60-page booklet entitled "Higher Holeage" is more of a handbook on electric drills than is the ordinary catalog. This booklet is divided into the following twelve chapters: The history of holemaking; holemaking by electricity; electric drills—the machine guns of industry; higher holeage—lower cost; unusual uses of Van Dorn drills; holes in a hurry for shop repairs; buy your drills for "holeage"; operation and care of electric drills; electricity versus air for drilling purposes; tools recommended for various wood drilling operations; America's finest family of holemakers. The chapter on operation and care of electric drills not only gives directions for their proper use, but also calls attention to the most frequent misuses of this equipment. Special attention is given to a discussion of the proper sharpening of twist drills.

American Optical Company, Wellsworth Safety Division, 700 West Fortieth Street, New York, N. Y.—A new catalog entitled, "Industrial Head and Eye Protection," shows a wide variety of goggles for dust and chip protection as well as welding masks, helmets, and goggles for the various types of welding protection. A chart shows the protection afforded by different lenses against the ultra-violet and infra-red rays.

Electric Machinery Manufacturing Company, Minneapolis, Minn.—Bulletin 854 entitled, "Synchronous Motors for Compressors," discusses the suitability of a compressor for a synchronous motor application, the selection of the motor, fitting motor to the compressor, fly-wheel effect and details of a special engine type motor, which is designed for direct connection to compressors.

The Foxboro Company, Inc., Neponset Avenue, Foxboro, Mass.—A group of bulletins describe the recording gages, thermometers and other instruments made by this company. Considerable emphasis is placed on the improved helical tube movement for controlling the movement of the recording pen.

Gregory Electric Company, Sixteenth and Lincoln Streets, Chicago, Ill.—"The Monthly Bargain Sheet" lists, describes and prices the various new and "Gregory Rebuilt" electric motors, generators, switchboards, transformers, various starting equipment and other apparatus on hand for sale.

Moloney Electric Company, St. Louis, Mo.—This company is distributing monthly bulletins containing technical information on transformer data made up in page form suitable for clipping and inserting in loose-leaf binders. The first of the series gave the method of connecting low voltage, single-phase distribution type transformers for different types of service. The second discusses the polarity of single-phase transformers, polarity—its meaning and marking, Moloney transformer data, and testing for polarity. The third of the series will contain a discussion of impedance of transformers and methods of measuring impedance.

Greene Equipment Corporation, Monadnock Building, Chicago, Ill.—A circular describes the new Leonard Morrow commutator tool which consists of a special bracket which is attached to the bearing and supports a turning tool for truing commutators of motors without removing the armature from the original bearing. Different size commutators may be trued by the use of large or small brackets on the same truing tool.

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.—A wall chart HC-233 entitled "Westinghouse Insulation Guide for Industrial Motors" shows in chart form the various Westinghouse insulating materials and insulating compounds for rotating and for stationary parts. This chart lists the various places where insulations are used and the different types of Westinghouse insulations adopted for each place.

Elgin National Watch Co.

(*Continued from page 559*)

Many of these steps are performed on special machines, some of which are shown in the accompanying illustrations. Some of the drills are so fine that they can hardly be seen. However, should one of these tools fail, the machine automatically stops and a signal flashes. The making of a balance wheel calls for a greater number of operations than are required by any other unit of the watch. For example, the rim alone is pierced with twenty-six threaded holes. These holes are made by a steel drill finer than a human hair. Over a million of these drills are required annually.

The mainspring and balance- or hair-spring are two important parts of the watch. The hairspring is made by drawing steel wire through a hole in a diamond. A pound of steel used for springs costs $5 or $6 and will make eight miles of hairspring wire worth $62,000.

The buildings at the Elgin factory are comparatively narrow and provided with a large window area to supply as much natural light as possible. This is supplemented by artificial illumination as care must be exercised to prevent eye-strain because much of the work of manufacture and assembly is performed under a magnifying glass.

Founded 1882 as Electrical Review | DECEMBER, 1924 | McGraw-Hill Co., Inc., Chicago, Ill.

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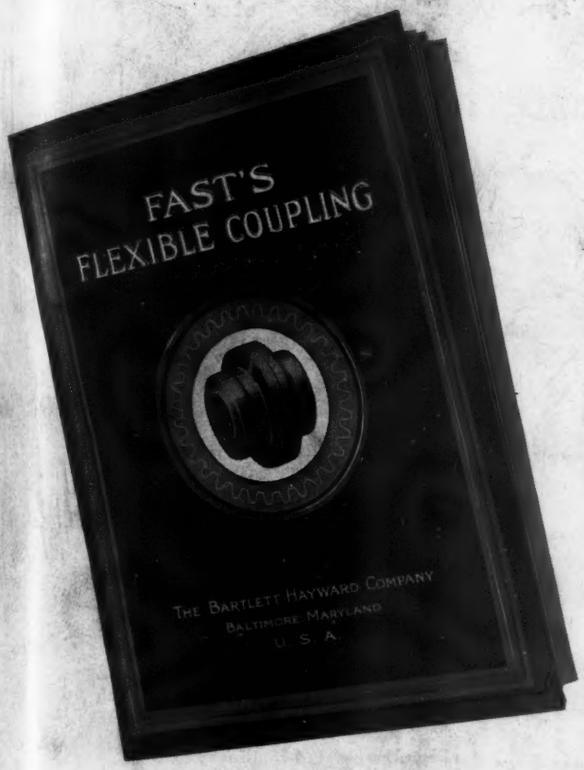

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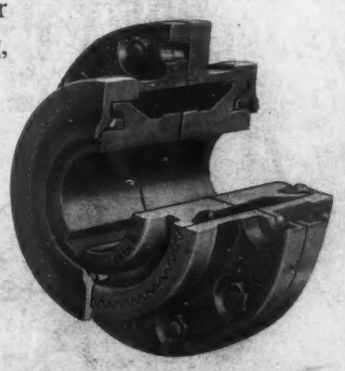

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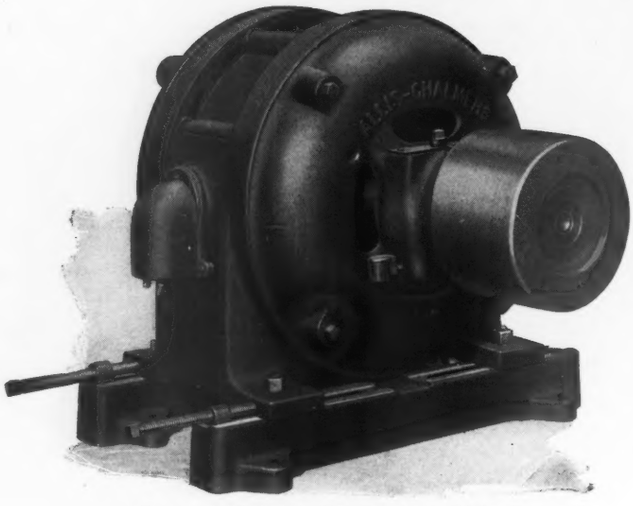

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

Founded in 1882 as Electrical Review with which was consolidated Western Electrician

D. H. BRAYMER, *Editorial Director*

Volume 82 *Number 12*

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Who Originates Orders Resulting from Maintenance Work?

THIS question is frequently asked by equipment manufacturers. It calls for more specific questions. For instance: Do you mean the man who issues the order? If so, he is the purchasing agent or possibly a clerk in the accounting department and his order is an approved requisition that has come from *someone else.* The purchasing agent can order only what this requisition specifies.

Do you mean the man who approves the requisition that the purchasing agent receives? If so, he may be the president of the company or he may be the manager or general superintendent. His approval means, "Yes, that's a good idea. Go ahead with it." His approval is usually in the form of "Yes" or "No." But he is not the man who finds the place for your equipment. *Someone else* saw the need of it, *someone else* visualized the benefits to be gained and started the ball rolling to get it.

Who then is this *someone else?* He is the man on the job. He has various titles and in many cases he has none. He is known as the superintendent, the chief electrician, the master mechanic, the maintenance superintendent, the mechanical superintendent, the electrical superintendent, the plant engineer, the electrical or mechanical engineer, and so on—titles without end that quite often mean little. Usually he is known as Joe or Bill or "the boss." From his daily contact and intimate acquaintance with the work to be done and his knowledge of the methods and equipment that are being made to do it, he originates the application of such methods to his own job. Naturally, he is the man who originates the requisition that eventually appears on a manufacturer's books as an order. This man, his foremen and his other assistants, are the men who must be sold, for they are the men who do the thinking that improves plant operations, and originate the orders for needed equipment.—*Practical Pete.*

McGRAW-HILL COMPANY, INC., OLD COLONY BUILDING, CHICAGO, ILLINOIS
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Three- and Two-Phase Constant Speed Squirrel Cage Induction Motors

½ to 15 H.P. (Types KT and KQ)
900 Series Frames
Continuous Duty—40° C.

To build motors that meet users' needs and to render service that insures satisfaction to the purchaser is the constant aim of the General Electric Company. Excellent mechanical and electrical construction in the new "900 series" motors insure exceptional operating characteristics.

Outstanding features of the "900 Series" are:

Electrical—

Ample starting torque and rapid acceleration.
Maximum pullout torque over 250% of full load torque.
Less than 6% slip.
Temperature rise at full load will not exceed 40° C.

Mechanical—

Large dustproof oil wells—frequent replenishment unnecessary.
Sliding base, easily mounted on wall, floor or ceiling—permits quick change of belt tension without affecting alignment.
Large conduit terminal box—facilitates making connections.
Paper pulley transmits full power at low belt tension.
Moulded insulation provides additional protection to well insulated field windings and also enables the motor to be operated successfully where exposed to magnetic or abrasive dust, or to weak acid or alkaline fumes.

The new 900 series motor does its work well, requires little attention, has a low maintenance cost, and uses power efficiently—just what every user wants.

General Electric engineers study the power requirements of all industries. Through adequate manufacturing facilities, their efforts result in a combination of motors and control closely adapted to the service to be performed.

General Electric Company
Schenectady, N. Y.
Sales Offices and Motor Dealers in All Large Cities

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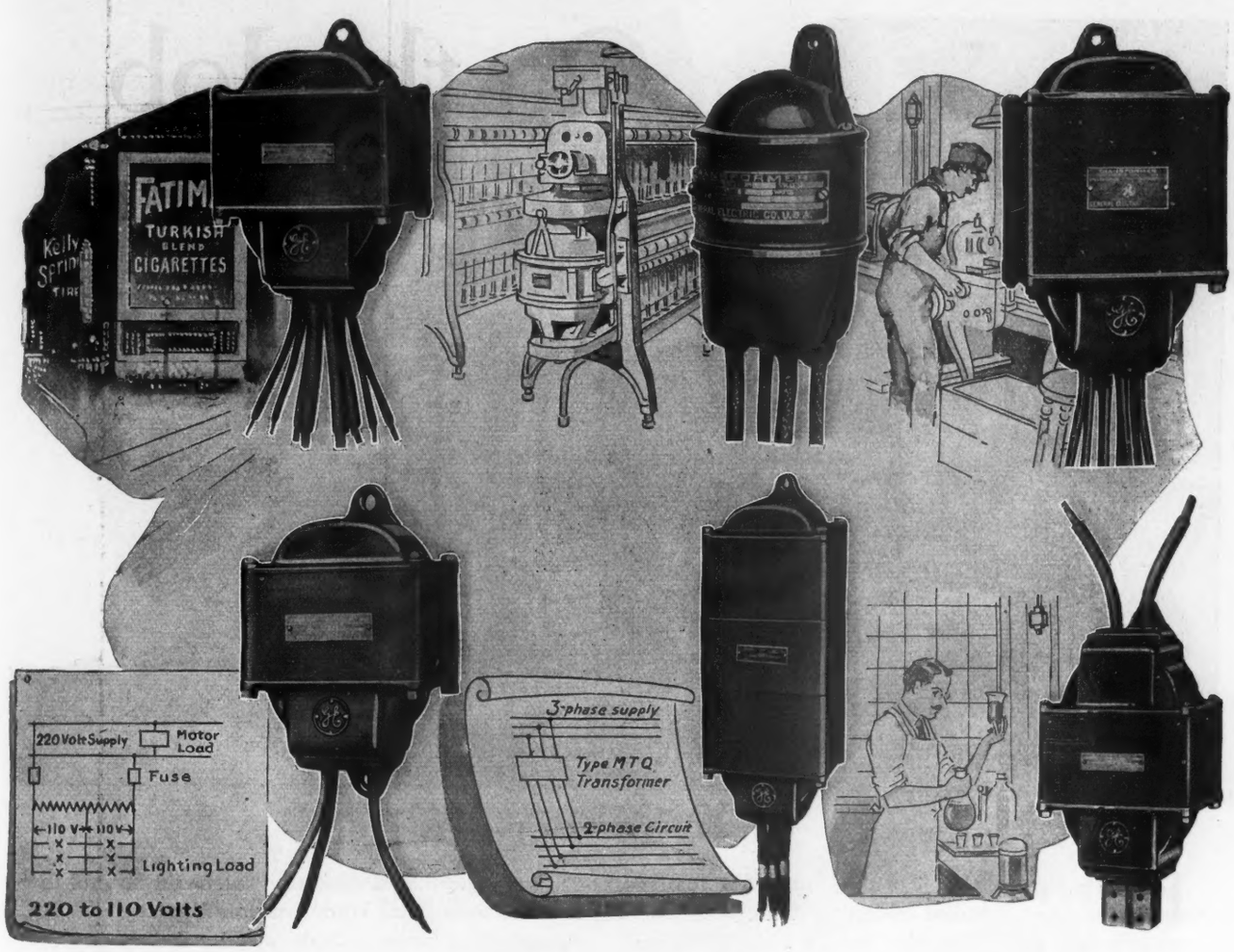
GENERAL ELECTRIC



Any *special* power needs? Investigate Type M's

"Type M" designates a line of miniature air-cooled G-E Transformers especially suited to purposes where a small alternating current, low voltage, is required.

These transformers are sufficiently attractive for installation where good appearance is desired; at the same time their sturdy construction permits installation out of doors or in other severe locations.

Sizes are 15 to 5000 watts, up to 550 volts, primary. But hundreds of ratings can be built at a minimum cost of manufacture and engineering, for Type M Transformers are simply assembled from a uniform line of Type M parts. Therefore, if you have any special requirements, *special* Type M's can be supplied.

Think of Type M's for special applications. Their greatest service lies in filling special needs. Tell the nearest G-E Office yours.

General Electric Company
Schenectady, N. Y.
Sales Offices in all Large Cities

33A-175

GENERAL ELECTRIC

On the Job *for over* TEN years

Monitor Automatic Controller installed on G. A. Gray reversing planer in the plant of the Marion Steam Shovel Company in 1913. The controller is still good for many more years of service.

IN 1913 the Marion Steam Shovel Company, Marion, Ohio, installed a Monitor Automatic Controller for the table drive of a 60-in. x 60-in. x 144-in. G. A. Gray reversing planer. During the ten years that this controller has been in use it has given complete satisfaction and is still good for many more years of service. Similar satisfactory service has been received from five other Monitor-controlled planer installations in this plant.

The controller for this reversing planer is equipped with two complete starters, each having its own accelerating units which are of the differential lock-out type. Reversal of the planer bed is accomplished through table switches which cause the 30-hp., 550-volt, d. c. Triumph driving motor to be automatically stopped, started in the reverse direction and brought up to speed in the shortest possible time consistent with a safe limitation of armature current.

The application of Monitor Automatic Control to machine tools of all kinds has contributed much to output of machines in both quantity and quality of production. This is so because Monitor controllers relieve the operator of all details of proper starting and control. They simplify machine control and allow the operator to keep his attention on the factors that most vitally affect his work. Monitor Automatic Control provides for starting, stopping and speed changes in accordance with a pre-determined program worked out by experts and requires not one bit of thought on the part of the operator.

Starters and controllers made up of standardized unit parts and elements can be quickly obtained to meet any standard or special conditions encountered in the operation of all kinds of machinery driven by either direct or alternating-current motors. Just put your problem up to Monitor.

Monitor Controller Company

BALTIMORE, MARYLAND

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Buffalo
Chicago
Cincinnati
Cleveland

The Original "Just Press a Button" System

Detroit
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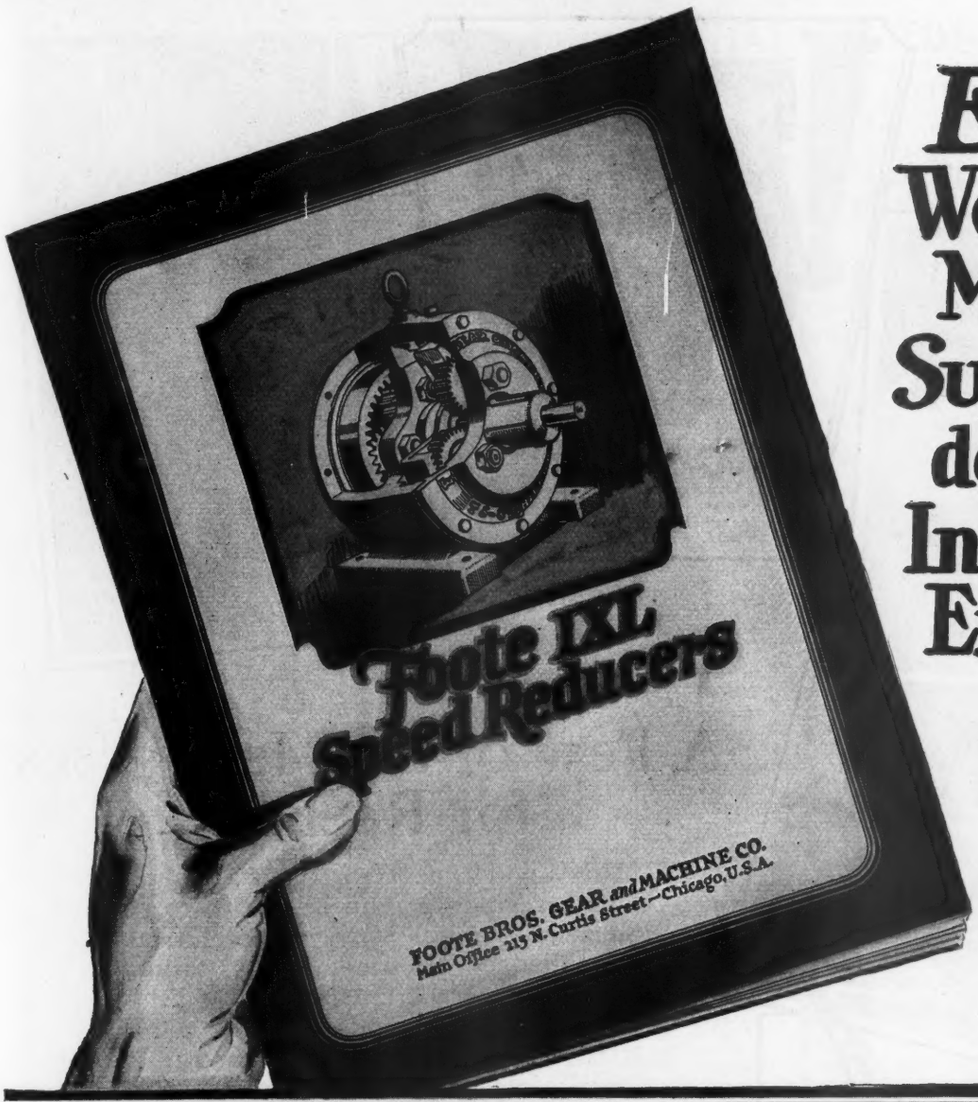

Every Works Manager Superintendent and Industrial Engineer should send for this FREE BOOK

Chuck full of Invaluable Information

Here is a book of 79 pages, chuck full of valuable information. It's designed to post plant executives and engineers on the uses, applications, advantages and operation of these modern speed reduction units which are rapidly replacing belts, pulleys, chains and open gearing in nearly every industry.

It's invaluable to anyone interested in machinery or production from any angle. It's a book you will want, and it will be sent to you free on your request.

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Established 1895

Established 1895

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CHICAGO, ILL.

Please send without obligation a copy of the Foote IXL Speed Reducer Book.

Signed_____

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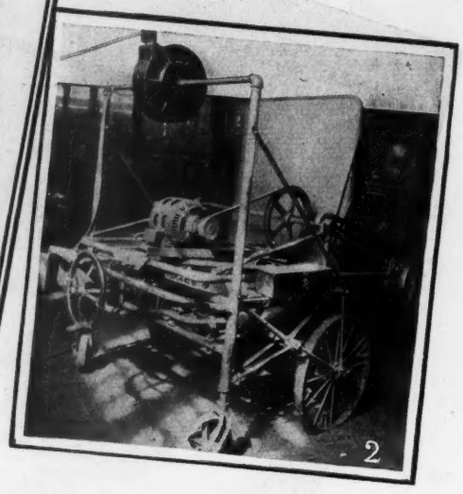
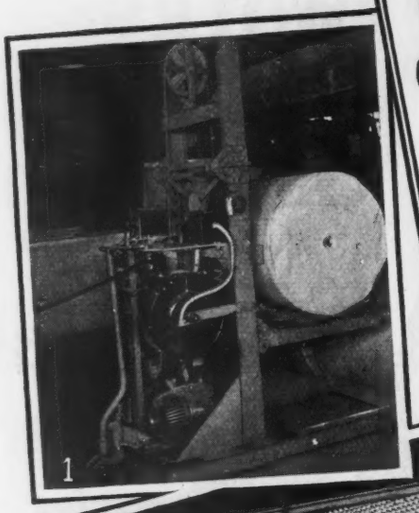
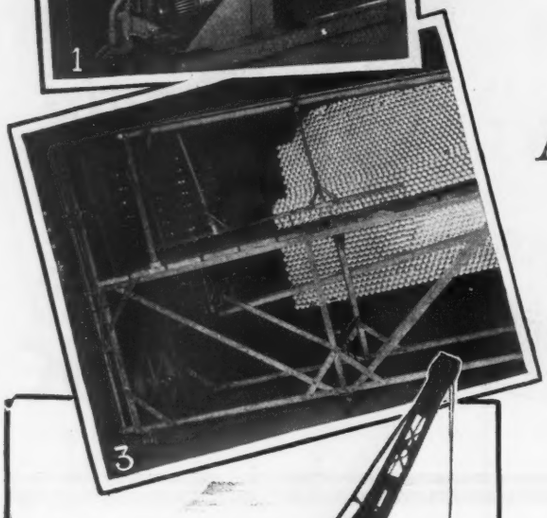
Mogul Type Reelite
There is a Reelite for every power extension requirement—the smaller sizes take care of portable tools and lights.







The Mogul Type Reelite is effecting savings on

1. Portable Elevator
2. Electric Sand Cutter
3. Can Stacking Machine
4. Crawler Crane with Electric Magnet.

A Few of the Many Uses for Reelites

THE Mogul Type Reelite finds a profitable use wherever power is to be carried to portable equipment — on all kinds of mobile machines, cranes, dredges, electric magnets, railroad and mining machinery, etc. The cord is kept coiled in a container, clean and unkinked, and is automatically unreeled and retrieved as the location of the equipment demands. This saves considerable time and trouble, and frees the cord from wear, which in turn keeps the machine in service — adding profits instead of losses.

Here are pictured some typical applications of the Mogul Type Reelite. Probably they can suggest a similar use for you.

Our engineers will gladly explain how it saves in operating costs, convenience, safety, and how it can be adapted to your requirements. Ask them.

APPLETON ELECTRIC COMPANY
General Offices and Factory
1718 Wellington Ave., Chicago

MOGUL TYPE
Reelite
REG. U.S. PAT. OFF.

KEEPS THE MACHINE IN SERVICE

This picture shows the effect of too much opposing light.
A brilliant light is a danger to the eye and an enemy of good work and production.

This picture shows the effect of half the light, shaded from the eye and directed where needed.
Axcess System is based on the principle of lighting from the correct angle.

WHAT DO YOU KNOW ABOUT EYES — YOUR MEN'S EYES?

IT WOULD MEAN NEW EYES FOR THE WHOLE PLANT

IF THE EXECUTIVE would apply his business observation to the importance of quick sight to the cost of production.

THE EXECUTIVE should take the operator's place to learn just what must be seen. He would then realize that the lighting requirements necessary for skilled work are very different from those required at his desk. Then something would happen quickly. The matter of light and sight improvement would be looked upon as a **needed investment and not an expense.**

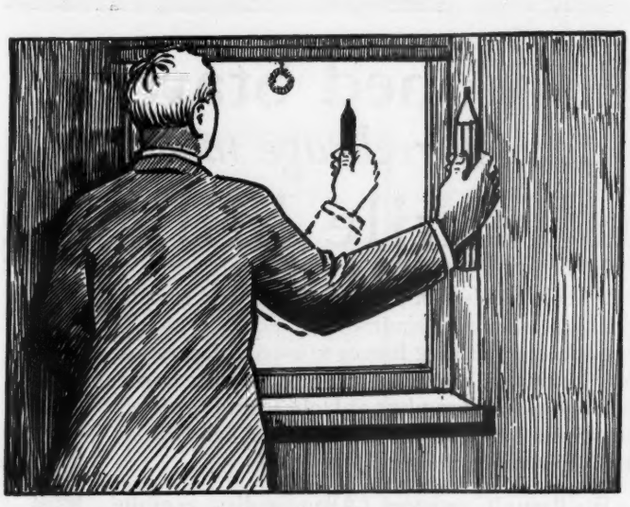
THE EXECUTIVE would then encourage workers and department heads in their efforts to better the lighting conditions because he would know that LIGHT, SIGHT, AND PAYROLL ARE EACH A PART OF DIRECT LABOR COSTS. Department heads and workers would no longer fear to request better lighting conditions.

THE EXECUTIVE, once he understands that most short-focused skilled factory operations require directional lighting, and often twenty times the amount his office does, he will take immediate action to obtain lighting that will mean nearer 100% efficient production.

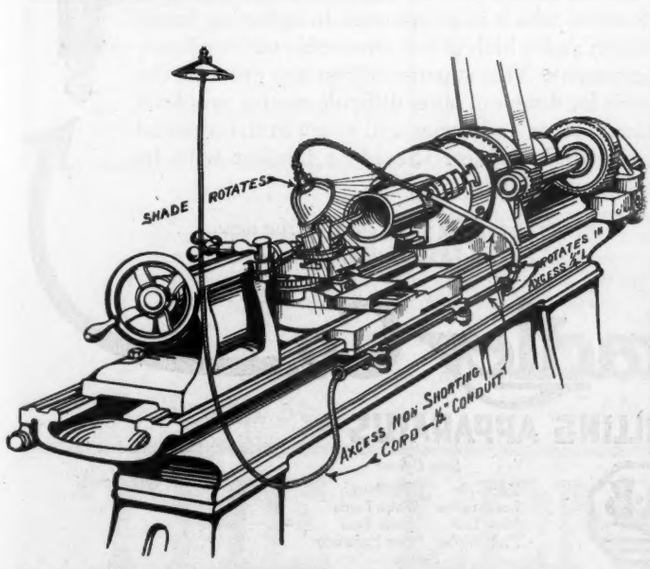
IF THE EXECUTIVE could give all his employees a pair of new eyes he would improve their eyesight —their ability to work and the amount and quality of the work they did.

WHEN THE EXECUTIVE installs Sampson Axcess System in his plant he is coming as near as is humanly possible to giving his employees new eyes for he is giving them light directly where it's needed —light that soothes the eyes, yet is giving them enough to make it easy to see quickly. He is giving them the means through which to accomplish more profitable work for him.

AXCESS SYSTEM applies to any type of manufacturing. Why not investigate?



Too much opposing light as shown by holding a pencil to the window, fails to show its size, shape or color. Using the wall as a darker background reveals the pencil in detail.
Axcess shaded and directed lights will not glare, will reduce fatigue and increase production.



This is Axcess Lathe Group No. G505L, furnished complete ready to put in use. Price $5.00. We will send on 30 days trial.

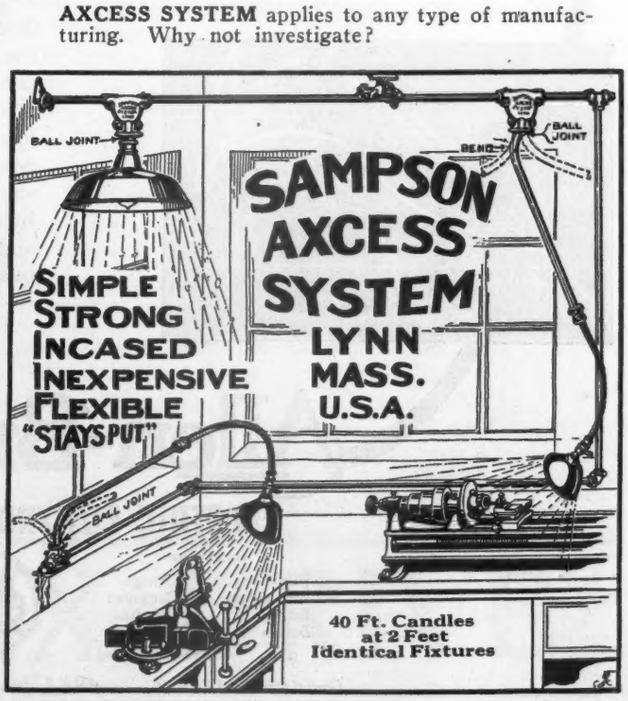
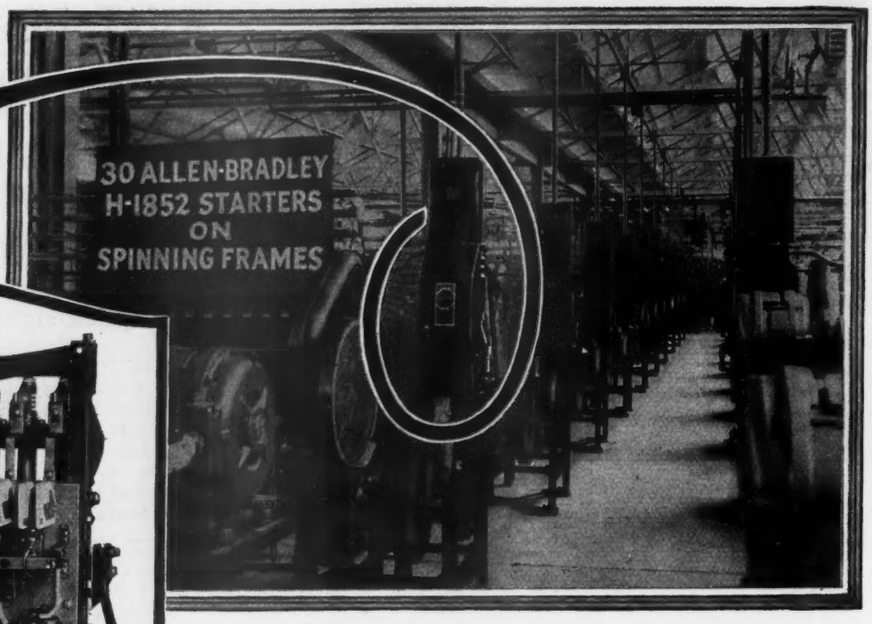
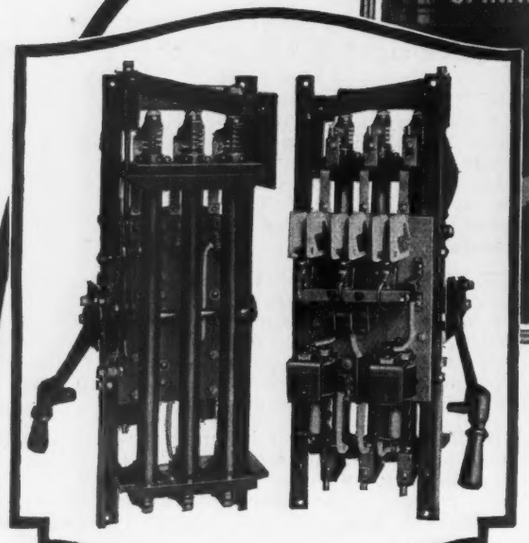


Illustration shows 10 of 30 H-1852 Resistance Starters in Barrymore Seamless Wilton Plant.





Cushioned Starting
for squirrel-cage motors
In Textile Mills

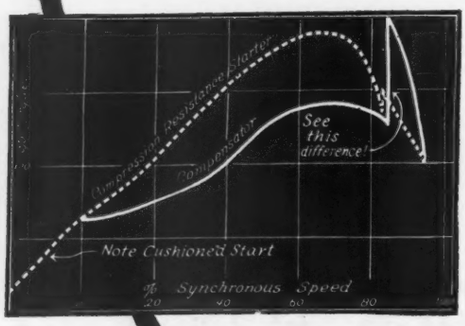
The difficult problem of jerkless starting and smooth gradual acceleration of squirrel-cage motors, which is so essential for spinning frames to avoid breakage of thread in starting, has been solved in the huge Barrymore Seamless Wilton plant at Holmesburg Junction, Pennsylvania, by the installation of Allen-Bradley H-1852 Resistance Starters.

The Bradleyunit resistors (Allen-Bradley graphite disc resistors, illustrated in the cross-section view at the right) used in the H-1852 Resistance Starter, provide the cushioned starting and smooth, gradual acceleration which is so essential in spinning frame operation and which is not obtainable with ordinary compensators. This superior starter also provides the solution for dozens of other difficult starting problems in many other industries and every mill, industrial and electrical engineer should be familiar with its unusual possibilities.

Write today for your copy of the new H-1852 Bulletin

H-1852 Superiority

Two distinctive features make the H-1852 Starter superior to ordinary compensators. First, the use of Allen-Bradley graphite disc resistors provides stepless regulation of resistance. Second, the motor is switched to full line voltage before starting connections are broken and current inrush is practically eliminated. The curves below show graphically why H 1852 Starters make good where ordinary compensators fail



Allen-Bradley Co.

ELECTRIC CONTROLLING APPARATUS

Sales Offices:
Baltimore, Birmingham, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit

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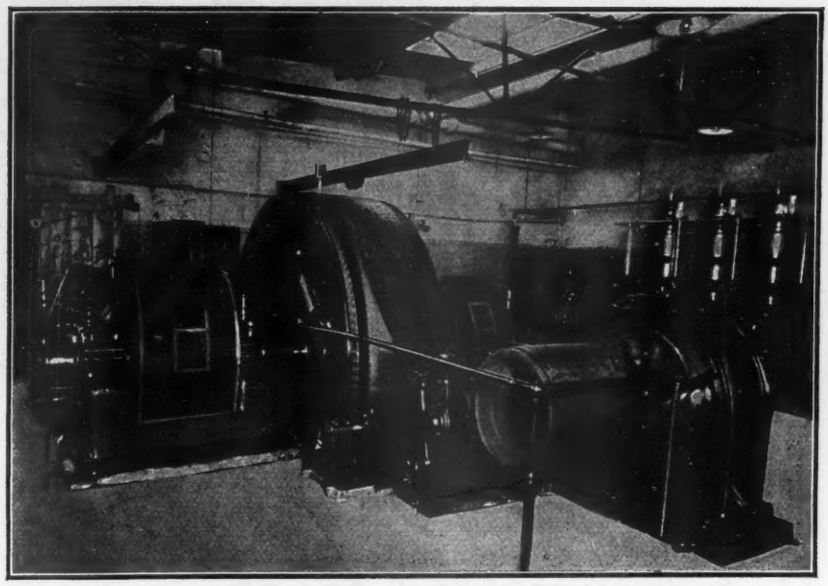
AT BOOTH Nos. 281 & 282 - POWER SHOW - DEC. 1-6

25% More Power from the Same Gas Engine

Saved—
31 feet of floor space

Saved—
62 feet of belting



300 H.P. Gas Engine driven Alternator Alternator pulley 27″ diameter, 27″ face, Pulley centers 10 feet. Engine pulley 114″ diameter, 31″ face.

This increase in the capacity of a 300 H. P. gas engine driven alternator is one of three highly important benefits derived by a western power company from the installation of a Lenix Drive. That company needed space for an additional unit. The Lenix reduced the floor space of 41 feet of the original layout to 10 feet. The space reduction of 31 feet enabled them to place the new unit in the same engine room. The cost of the addition to the building was saved. The new belt is approximately 62 feet shorter than the original belt, and this saving in belting was more than sufficient to pay for the Lenix.

In the words of the general manager of the power company,

"We were able to shorten our belt centers approximately 31 feet; this has meant a great saving to us in room and permitted room for an additional unit. The drive has also been very helpful by eliminating belt slippage and belt trouble generally and increasing the capacity of the unit about 25%. It has also increased the life of our belt and we are highly pleased with the operation of this drive from that standpoint as well as the saving of space."

Five Points:

1—The Lenix increases the arc of contact between belt and pulley.
2—The Lenix maintains constantly and accurately the proper tension in the slack side of the belt.
3—The Lenix saves floor space, building space and belting because of freedom in pulley locations.
4—The Lenix saves in bearing friction, lubrication and renewal of bearings because of reduced bearing pressure.
5—The Lenix permits the use of less expensive, high speed and high efficiency motors or generators because of the higher pulley ratios.

The Lenix will be exhibited at the Power Show, December 1-6 at Booth 281-2 on the Mezzanine Floor. There will be a visual demonstration by the stroboscopic method of the elimination of belt slippage and increase in capacity of the Lenix short center belt drive over the ordinary open belt drive. Everyone interested in the transmission of power from one unit to another should see this demonstration and all who visit the Power Show are cordially invited.

Send for booklet Saving Slippage and Space.

F. L. SMIDTH & CO.

50 Church St. ***ENGINEERS*** **New York, N. Y.**

THE LENIX DRIVE

(Registered)

Vic Henson of Syracuse makes a hard tackle. His dive was nicely under the stiff arm and he is bringing his man down hard.

Photo by Underwood & Underwood

Lafayette working a triple pass against Pittsburg. This remarkable picture shows Miller, Lafayette r. h. b., just after catching a triple pass. If he could have kept his feet he would have had a clear field ahead of him.

Chicago 20
Belt Trouble 0
Third Quarter

A veteran Chicago Belting Reliance 3-ply finishing up its 21st consecutive year of service as the main drive of a big cement plant in Southern Indiana. It is 72 inches wide and is one of five big belts on the main drive of five big factories in the same town—each 72 inches wide—each a veteran of over 20 years' continuous service.

Between the first and last chalklines

Grange, stopped behind the line, is no better than any other halfback. But give him a little patch of clear field ahead of him and with his tremendous driving power he will run, twist, turn, hip-dodge and straight arm his way over the flying chalklines to a touchdown.

If stopped before he reaches the first chalkline he is stopped completely. But once you get him over the first chalkline nothing can stop him before he has crossed the others like a scared jack-rabbit.

In the field of power transmission by belting the years of service a belt gives corresponds to the number of chalklines that mark the progress of the hurrying, brilliant halfback on the football field.

A Chicago Belting pre-tested leather belt in the stock room is no better than any belt in any stock room. But put them on the pulleys and they will soon enough demonstrate how good they are.

Into every Chicago Belting pre-tested belt is built the very utmost years of service. Guiding every selection of our leather—back of every carefully done bit of workmanship—behind all of the tests we make is the one thought **"How will this belt be twenty years from now?"**

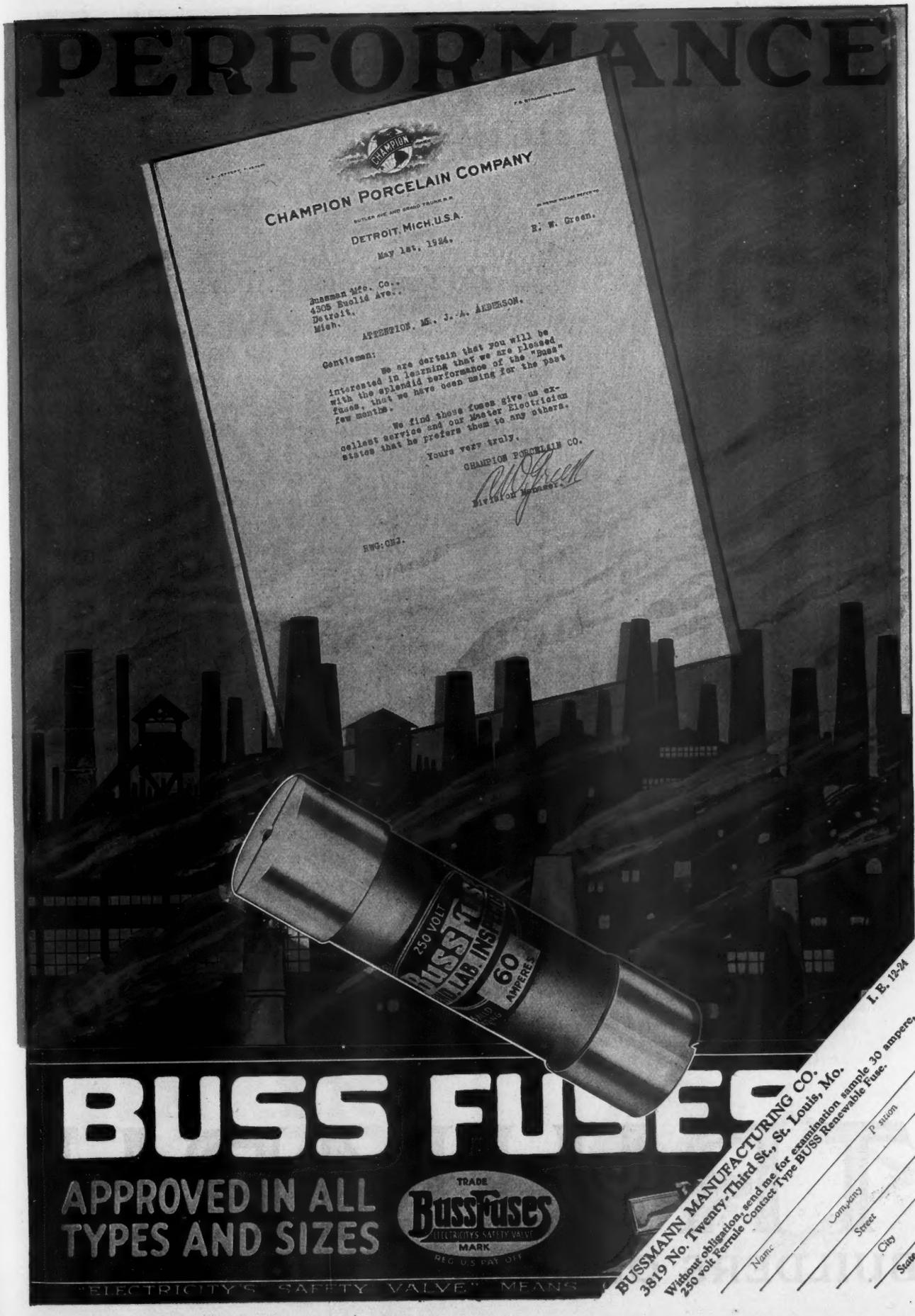
The great pride of our factory is in the fact that Chicago Belting belts last so long on the pulleys. To make belts that will deliver two years where others last but six months—to make belts that will serve for five years where others serve but two—to deliver a ten-year belt to replace one that lasted four years—**that is our special accomplishment here at Chicago Belting.**

Why not have us figure with you on your next order?

Chicago Belting Company
New York, Boston, Pittsburg, Cleveland, Minneapolis, Rockford
Manufacturers of Leather Belting
110 North Green Street, Chicago, U.S.A.
New Orleans, Los Angeles, San Francisco, Portland, Ore., Seattle, Wash., Atlanta

Chicago Leather Belting

Thomas of Chicago breaks away for twenty yards.


PERFORMANCE
CHAMPION PORCELAIN COMPANY
DETROIT, MICH. U.S.A.
May 1st, 1924.
E. W. Green.
Bussman Mfg. Co.,
4305 Euclid Ave.,
Detroit,
Mich.
ATTENTION, MR. J. A. ANDERSON.
Gentlemen:
We are certain that you will be interested in learning that we are pleased with the splendid performance of the "Buss" fuses, that we have been using for the past few months.
We find these fuses give us excellent service and our Meter Electrician states that he prefers them to any others.
Yours very truly,
CHAMPION PORCELAIN CO.
Division Manager.
EWG:CMJ.
250 VOLT
BUSS
LAB. INST.
60
AMPERES
BUSS FUSES
APPROVED IN ALL TYPES AND SIZES
TRADE
BussFuses
ELECTRICITY'S SAFETY VALVE
MARK
REG. U.S. PAT. OFF.
"ELECTRICITY'S SAFETY VALVE" MEANS
I. E. 12-24
BUSSMANN MANUFACTURING CO.
3819 No. Twenty-Third St., St. Louis, Mo.
Without obligation, send me for examination sample 30 amperes, 250 volt Ferrule Contact Type BUSS Renewable Fuse.
Name
Company
Position
Street
City
State

They Used to Crank the Old Things

Do You Believe in Crank Handles?

It has been a long time since crank handles were used to start automobiles. Still, the advantages of starting automobiles mechanically are small beside the dollars and cents advantages established in the past eight years by the TR self-start motor.

Do your mechanics walk ten feet (or more) to start the motor or do they push a handy button? Do you depend on starting devices or can you "throw 'em across the line" and profit by these TR savings: less space required for installation—elimination of control apparatus—saving of power—reduction of the wastes of overmotoring and—savings of capital investment.

Here is the motor for that job. The reliable, foolproof, self-start motor that requires only a knife switch or inexpensive push button control.

Eliminate crank-handles from your shop. Demand TR self-start motors from your suppliers; specify them on your orders. Bulletin 128 will give you even more good reasons why.

THE TRIUMPH ELECTRIC COMPANY, CINCINNATI, OHIO

The only A.C. Self-Start Motor Built in sizes from 3 to 125 h.p., also Slip-Ring and Squirrel Cage Types from 1 to 250 h.p. Semi-Self Start Motors, Direct Current Motors, Elevator Motors, Special Motors, Motor Generator Sets, and D.C. Generators

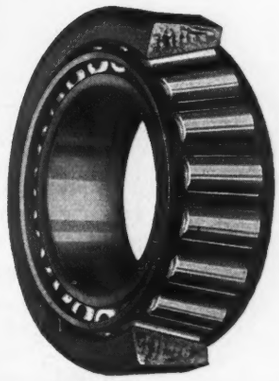
Sales Offices in Principal Cities

TRIUMPH

BUILDERS OF MOTORS SINCE 1892

Ruggedness

is the outstanding feature of Dodge-Timken Roller Hanger Bearings. It insures continuous power savings, trouble-free operation and negligible maintenance. Guaranteed by Dodge-Timken quality and performance.



DODGE TIMKEN
ROLLER HANGER BEARING

DODGE MANUFACTURING CORPORATION
General Offices: Mishawaka, Ind. *Works:* Mishawaka, Ind., and Oneida, N.Y.

Send for the "FACTS BOOK." It gives the whole story

EVERYTHING FOR THE MECHANICAL TRANSMISSION OF **Power**

New! in name only!

CASS commutator smoothing stones

TYPE C

Yes, it's the well-known CASS (formerly Aetna) COMMUTATOR SMOOTHING STONE—a new name, but the same quality. A stone that outwears any other smoothing stone. No change in sizes or styles. Made to meet all conditions.

TYPE W—DOUBLE HANDLE

THE illustration on the left shows the CASS grinding down the commutator of a large G. E. Rotary Converter in a big electric railway substation.

Notice the lever made from 2 x 4 timber for obtaining necessary pressure.

Middle illustration shows finishing process, namely, polishing the commutator.

On right is shown application of the stone to collector ring side of same rotary.

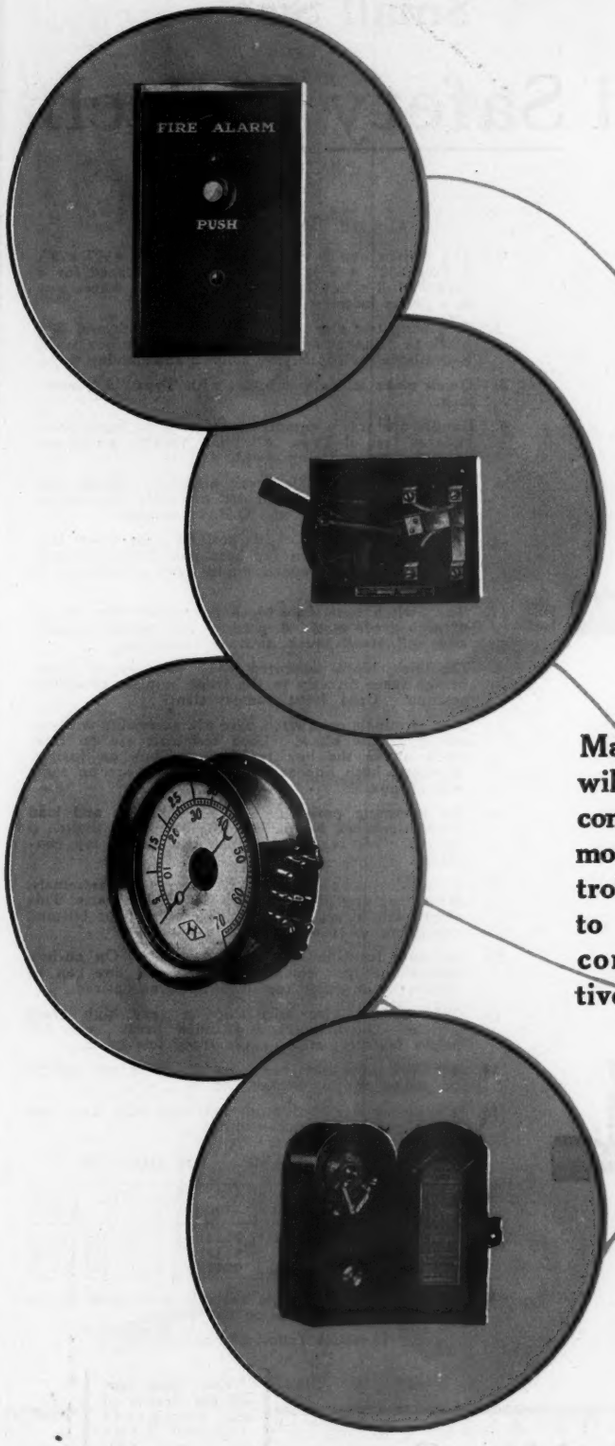
CASS Smoothing Stones remove all scores in the commutator and undercut the mica at the same time. They remove the undesirable glaze on the commutator and thus restore the original highly efficient surface.

Write today for Bulletin

ELECTRIC SERVICE SUPPLIES Co.

PHILADELPHIA 17th and Cambria Sts.
PITTSBURGH 629 Oliver Building
NEW YORK 50 Church St.
SCRANTON 316 N. Washington Ave.
CHICAGO Monadnock Bldg.
BOSTON 88 Broad St.
Lyman Tube & Supply Co., Ltd., Montreal, Toronto, Winnipeg, Vancouver

"DIAMOND H"

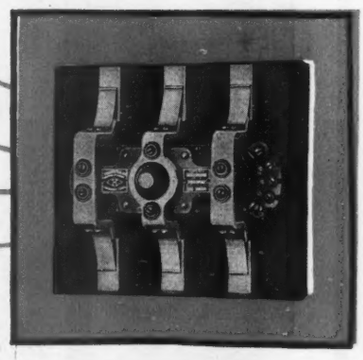


Remote Control Switches

What are your remote control problems? Diamond H remote control switches are used for all sorts of purposes.

Fire alarm systems—flood lighting—motor control and heating units. Operation from push buttons—thermostats—pressure regulators—time switches or tank switches.

Maintenance men will appreciate the construction of Diamond H remote control switches—easy to install—durable contactors—positive in operation.



Diamond H engineers are at all times available. They will gladly co-operate with you in the solution of your remote control problems. Write today for "A MANUAL OF REMOTE CONTROL EQUIPMENT."

The Hart Manufacturing Company
Hartford, Connecticut

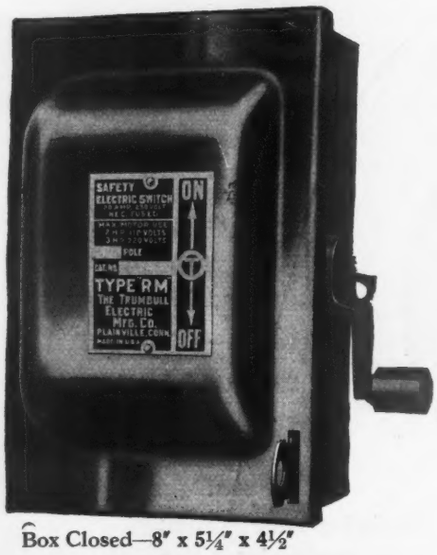
NEW YORK—BOSTON—CHICAGO
DENVER—LOS ANGELES—TORONTO
LONDON, ENG.

Just the Switch for use with Small Motors in Industrial Plants or on Lighting Circuits

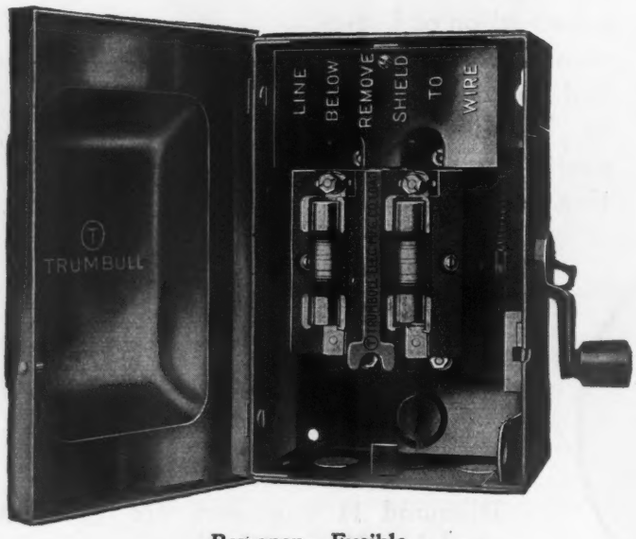
—the "R.M" Switch

Small Size

Full Safety Switch



Box Closed—8" x 5¼" x 4½"



Box open. Fusible
Fuse block and shield are reversible

30 AMP. 250 V.—2, 3, 4 POLE

1. The Switch box is very compact (2 Pole 4½" x 8", 3 Pole 6¾" x 8"), meeting a long-felt need for a rugged, full safety article for installation where size is a prime factor.
2. Removing two screws enables entire Switch and fuse block to be taken from box. Thus, entire box space is available for connecting conduit and running wires.
3. Quick make and quick break with Type "A" interlock.
4. Handle operates a compression spring on same principle as rest of Type "A" line. Handle would operate Switch if spring should fail.
5. Constructed on double break principle. Blades are carried by a rotor of moulded material, actuated by the cam of the Q.M. and Q.B. mechanism.
6. When blades are in "off" position they throw into deep narrow slots in the base and thus effectually snuff out any arc which might have a tendency to follow.
7. The Switch base, fuse block base, and rotor are all of high grade moulded material of unusual strength, and will stand much abuse in handling.
8. The fuse block mounted over the Switch base, brings fuses directly to the front in most accessible position. Dead front construction.
9. Line terminals on Switch base are accessible without removing fuse block. Load terminals are on fuse block above the line terminals. Thus on fusible Switches, both line and load terminals are on same end of box.
10. By reversing position of fuse block, line and load connections can be made at the bottom of Switch if desired. We regularly furnish the Switch top connected.
11. A shield attached by one screw covers line terminals, preventing any possible contact with live parts. This shield will fit only on terminal end, top or bottom, depending on position of fuse block.
12. Switches furnished fusible or no fuse. On no-fuse Switch the fuse block is omitted and line can be connected at either top or bottom, as desired.
13. This Switch gives the trade a very high grade article. Quick make and quick break, with full safety features, at an exceedingly low price.
14. 440, 550 volts Switches. 2 and 3 Pole will shortly be placed on the market.
15. Handle is a ribbed steel punching with cast iron knob—practically indestructible.

NO FUSE 250 30 AMP.				FUSIBLE 250 V.			
Cat No.	Pole	Volt	List Each	Cat. No.	Pole	Volt	List Each
46221	2	250	$4.80	92221	2	250	$5.50
46321	3	250	6.00	92321	3	250	7.00
46421	4	250	8.50	92421	4	250	9.50

We can furnish 3 p. fusible switches with solid neutral at regular price on request.

Discount Trumbull Schedule C

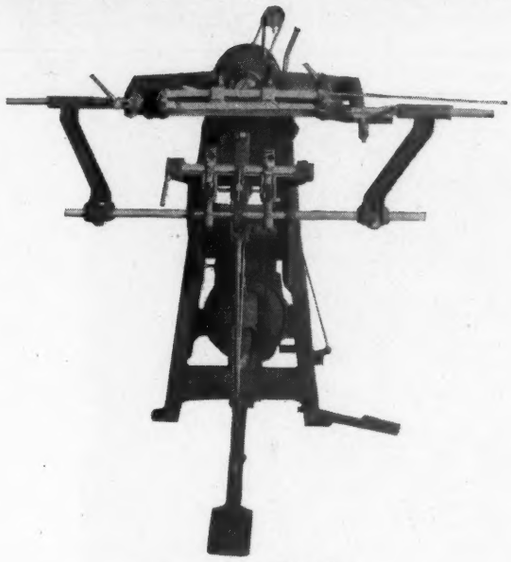
[You can get all the details of the complete Trumbull Line by asking your jobber for Bulletin No. 5.]

The Trumbull Electric Mfg. Co.

Plainville, Conn.

New York 114 Liberty St. | Boston | Chicago 2001 W. Pershing Road Atlanta, Ga. | Philadelphia | San Francisco 595 Mission St.

The New "Master"

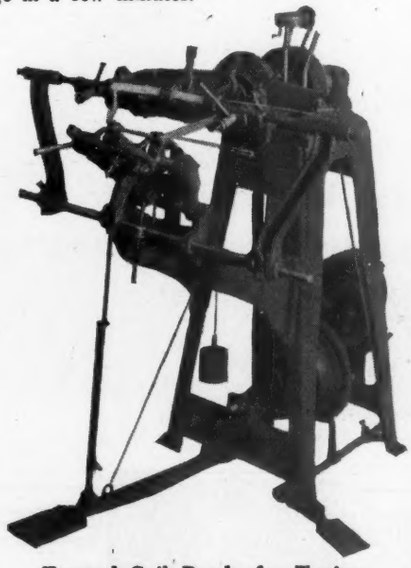


Loop After Winding

Loop Winding jaws are acuated by a universal single lever movement, that permits the coil end holder chuck to hold coil while forming, winding jaws are returned to winding position after forming coil.

The Loop is wound into the two upper pitched jaws that will be form fitting with slots after coil is completed.

The New "Master" is fully adjustable to a large range in a few minutes.



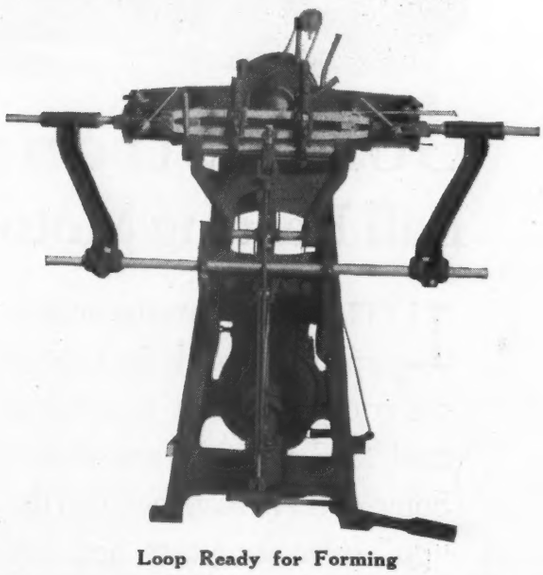
Formed Coil Ready for Taping

Brings Forth a Higher Art in Coil Making for Armatures and Stators.

Simplicity-Speed and accuracy are well abound in our new development that will rank-out foremost in the coil making industry and be appreciated by many in the future.

Our new product comprises a whole coil making equipment built in one unit, that winds and forms (not spread) but forms a perfect coil, same as the old fashioned form coil in less time than it takes to wind a loop only, by present methods.

Coils are wound and formed from original setting insuring positive uniformity that cannot be expected by present methods due to the handling between operations.



Loop Ready for Forming

There are numerous time saving advantages built in this machine that will convince the big production possibilities on the new "Master."

Coils are taped after forming, Stator Coils with ends taped only, are taped before removing from machine, eliminating the binding and unbinding, this time alone tapes the coil.

A "Master" Booklet describes every detail of this machine, and will be mailed at your request, visitors are welcome to a demonstration at our factory.

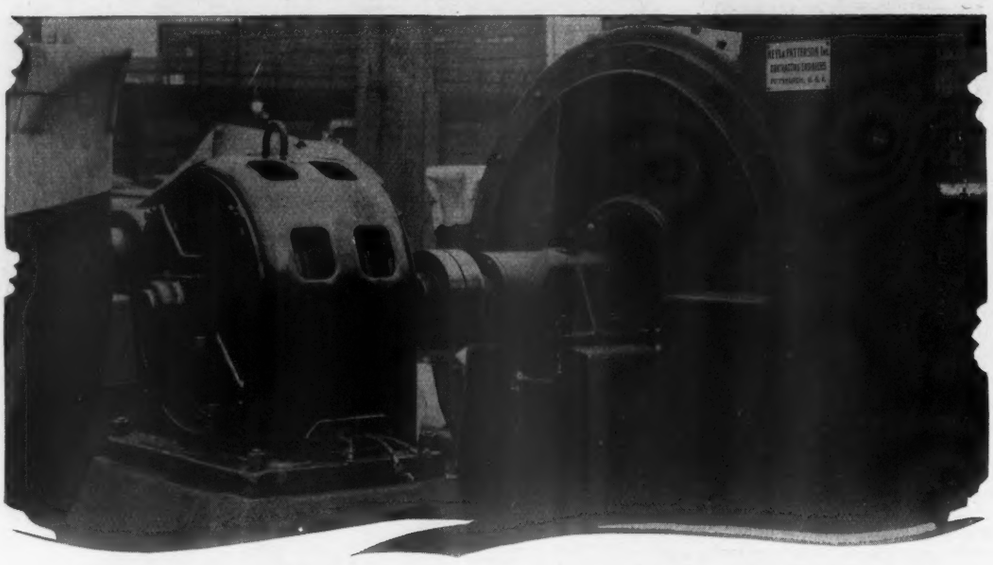
PATENTS GRANTED—OTHERS PENDING

Manufactured by

ARMATURE COIL EQUIPMENT CO.

2415 Forestdale Ave. **Cleveland, Ohio**

SKF



Going Strong for Six Years

Ball Bearing Motors on Coal Feed Fans

LITTLE work for the motor repair man with the type of electrically driven powdered coal feed fans shown above. Some of them have been on the "go" over six years and are still giving reliable service.

The high precision and inherent long life of Skayef Self-Aligning Ball Bearings are a positive assurance of low cost and trouble-free operation.

THE SKAYEF BALL BEARING COMPANY

Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

1289

Normal View *Deflected View*

CHROMALOX
Trade Mark Reg. U. S. Pat. Off.

This is the age of the Specialist

Showing Strip Heater in Case and Air Duct of Heater Case

This entirely new and self-contained heater complete in case delivers the maximum heat in the room on a minimum input of electrical energy. Various designs and sizes can be had to meet your requirements.

Doing one thing and doing it well has been our creed.

We are the only manufacturers making heating units exclusively.

The result is a superior product and genuine service to our customers.

We claim to make the most durable and efficient Strip Heater on the market and that we are HEATING SPECIALISTS, well equipped to serve you.

Thirty standard Strip Heaters in 8", 12", 15", 18", 21", 24", 30" and 36" lengths with various wattages up to 3000 in the 36" size can be supplied from stock and additional lengths up to 72" on special order.

Strips with both terminals at one end and in ring form in various sizes can be supplied.

The Railway Utility Company of Chicago is sole distributor of CHROMALOX Strip Heaters for use in heating of railroad and Street Cars in United States and Canada.

Our various offices will be pleased to co-operate in connection with your requirements. Let us have your inquiry.

A unit for every application.

Send for Booklet

Edwin L. Wiegand Co.

422 First Avenue,
Pittsburgh, Pa.

Edwin L. Wiegand Co.,
422 First Ave.
Pittsburgh, Pa.
Send me booklet (F-10-1) "Chromalox" Strip Heaters

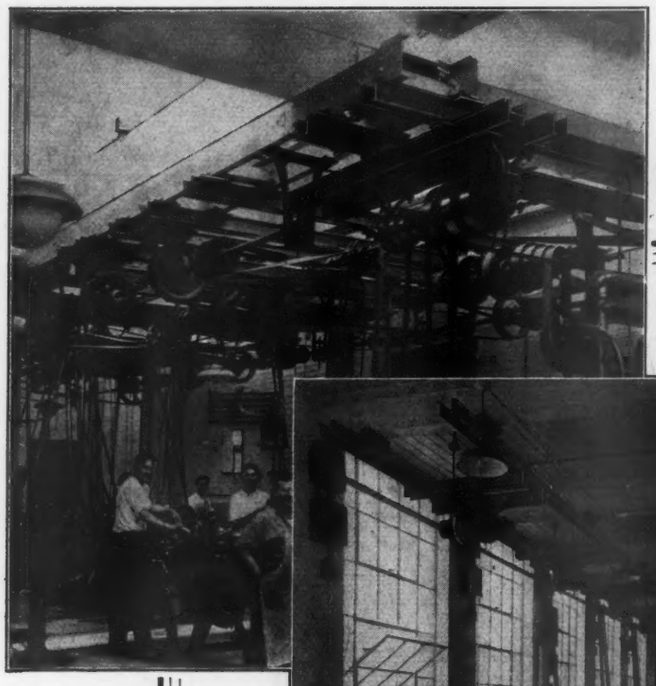
Name .....

Company .....

Address .....

City .....

FLEXIBILITY
IN YOUR
Overhead Layouts



Midwest Stringers clipped to I-beams, carrying short Midwest cross Stringers.

Midwest Stringers carrying overhead motors.

Midwest Stringers in mill-type construction.

MIDWEST STEEL STRINGERS

eliminate loss of time, skilled labor, rigging, drilling of holes and many other expensive troubles that come up when you have to change the layout of your overhead equipment.

Ready for use in the lengths you want, they are quickly and easily **clipped** in place—a bolt wrench is the only tool you need. When changes are necessary, or when new equipment is to be installed, either the stringers or the equipment attached to them can be rapidly shifted to the new positions involved. Belts do not have to be cut or relaced. Simply loosen the motor or shaft hanger and shift until the belt has the required tension.

Midwest Steel Stringers can be used on any type of building, with any kind of superstructure, providing a flexible, fireproof system of supports that cannot warp, shrink or check.

Write for a copy of Data Book S-20

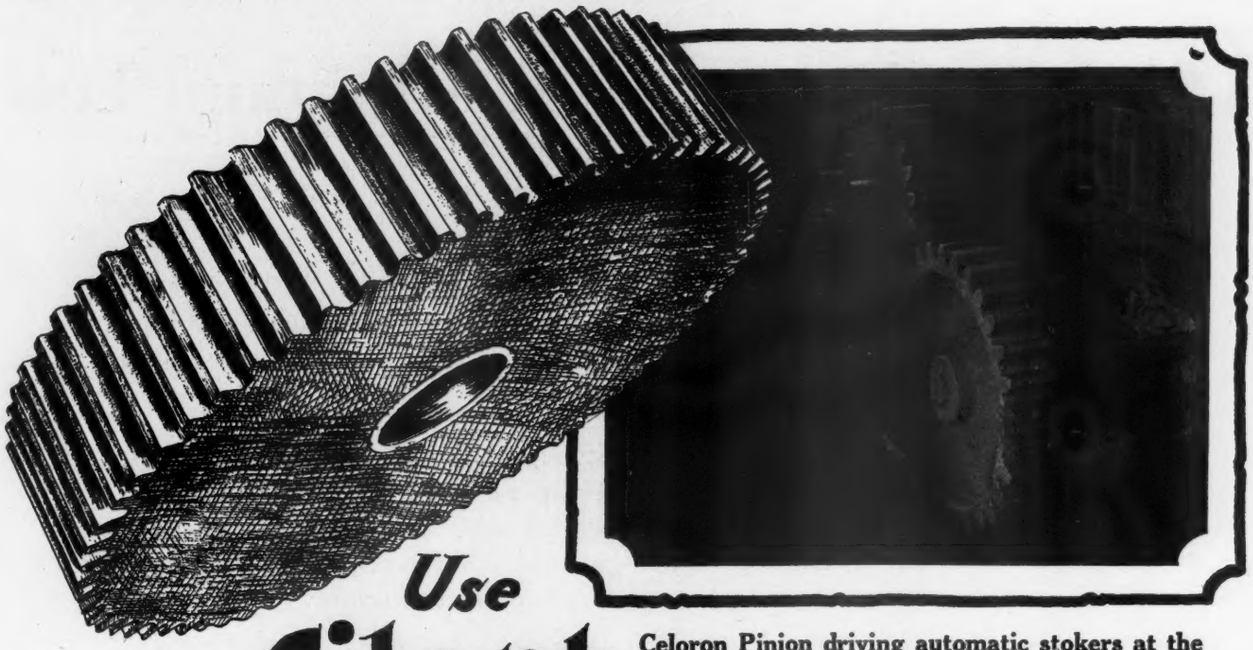
MIDWEST STEEL & SUPPLY CO. INC.

100 East 45th Street, New York City

Midwest Canada, Ltd.
83 Craig Street, West
Montreal, Canada

Midwest Pacific, Inc.
Monadnock Building
San Francisco, Cal.

On automatic stokers ——



Celoron Pinion driving automatic stokers at the Philadelphia Suburban Gas and Electric Co., Combrie, Pa.

Use Silent CELORON Gears

from

Mr. Daniel, Plant Supt.

This illustration shows a Celoron Pinion driving cast steel gear on automatic stokers at our plant at Combrie, Pa. The Celoron Pinion is 15.333 diameter by 4 inch face, 21 teeth. We have been using this installation for some time and results are so satisfactory that we plan to replace with Celeron on the rest of our stokers.

Daniel, Plant Supt.,
Phila. Suburban Gas & Electric Co.

♦F♦F♦F Wherever unusual gear service is necessary ♦F♦F

Silent Celoron Gears and Pinions cut down wear and tear—reduce maintenance and repair costs and last longer than metal. They are acid-proof. Grease, oil or water does not effect them.

Layers of woven fabric impregnated with synthetic resin bonded together at high temperature under great pressure make "Celoron"—a self-supporting material. Gears cut from it require no end pieces or shrouds and by actual operating data they last three or four times as long as others.

Any type of gear may be cut from Celoron.

Plant Superintendents in hundreds of plants in all kinds of industry are getting real results from Celeron Gears. Some interesting savings are being made because:

The resiliency of Celoron absorbs shocks and strains, thus cutting down wear and tear on other parts of machines.

Wear on mating gears and bearings is reduced to a minimum.

Tear down and maintenance costs are greatly reduced.

Mr. Daniel quoted above is only one of hundreds of plant superintendents who are enthusiastic Celoron users.

Send for Celoron Gear Book No. 3, which illustrates and describes installations of Celoron Gears in various plants and gives valuable data.

DIAMOND STATE FIBRE COMPANY
Bridgeport (*near Philadelphia*) Pennsylvania
Makers of
Diamond-Fibre-Celoron

Delivering Power With Minimum Loss

ECONOMICAL delivery of power through your line shafting is as necessary to profitable plant operation as proper methods in the generating and applying of the power.

The principal requirement is the installation of line shaft bearings that eliminate dragging friction and which possess the strength and positive lubrication features required by such service. Many successful plants have solved the problem by using Hyatt line shaft roller bearings.

These bearings eliminate from 50% to 80% of the dragging friction of plain bearings—thereby saving 15% to 25% of the total power transmitted. This saving means either reduction in power costs or a surplus of power for the operation of additional machinery.

Other advantages are 80% reduction of lubrication costs, dependable operation and long life—some have operated 33 years.

It is an easy matter to make the change. Hyatt bearings are split and can be installed without removing belts, pulleys or other shaft equipment. No delays or holdup of production.

Two tools—a wrench and screw driver—and a few minutes time of an ordinary millwright are all that are required for the job.

And the cost—very low when considered as an investment. The resulting economies will pay the cost of the bearings in one to two years. After that these savings can be counted as clear profit.

For new plants and old, Hyatt line shaft bearings are paying investments. *Write for Bulletin 130.* It contains information of interest and value.

'Phone the Nearest Mill Supply Dealer

HYATT ROLLER BEARING COMPANY
NEWARK, NEW JERSEY
PACIFIC COAST ADDRESS: SAN FRANCISCO, CAL.

HYATT ROLLER BEARINGS FOR LINE SHAFTING

Steel Clad!

Sturdy fighting men of old fought clad in steel armor from head to foot and so—are the CONDIT types F-8 and F-9 armored with steel from top casting to cradle —to withstand battles encountered in service.

Steel—top, tank, cradle—wherever steel is best steel is used, providing maximum mechanical strength.

This coupled with four series breaks per pole affords high interrupting capacity and a high factor of safety. Truck type—units mechanically interlocked, or if you prefer platen mounted.

They're built for service and they give it.

"*Get in touch with Condit*"

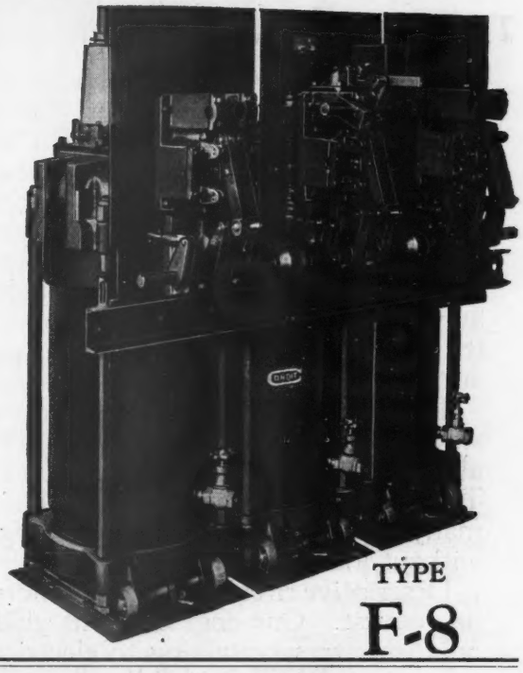
CONDIT ELECTRICAL MFG. CO.

Manufacturers of Electrical Protective Devices

South Boston, Mass.

Northern Electric Company LIMITED

Sole Distributors for the Dominion of Canada

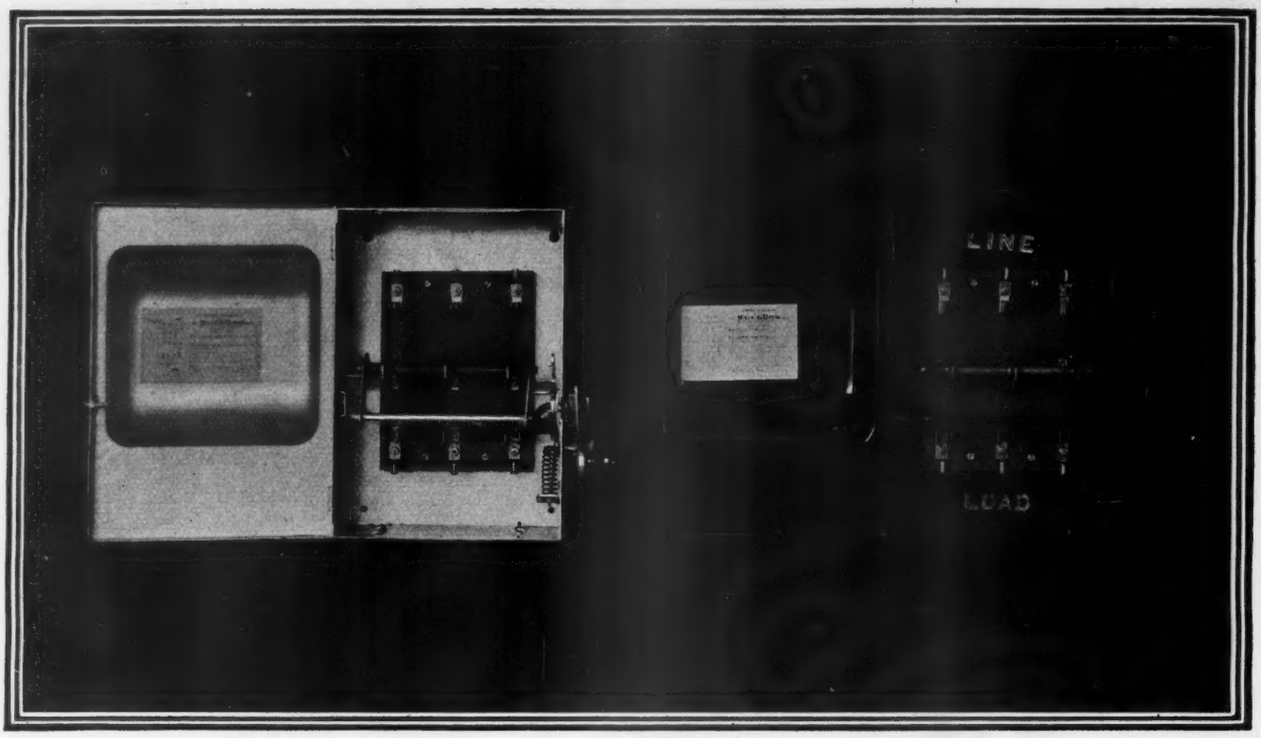


TYPE **F-8**

Specifications: Standard capacities for 15,000 or 25,000 volt service. Interrupting capacity: F-8, 18,000 amperes at 15,000 volts; F-9, 30,000 amperes at 15,000 volts.

7410

CONDIT



"Luminized" Bull Dog Safety Switch *Black Finish Safety Switch*

Visible In the Dimmest Light

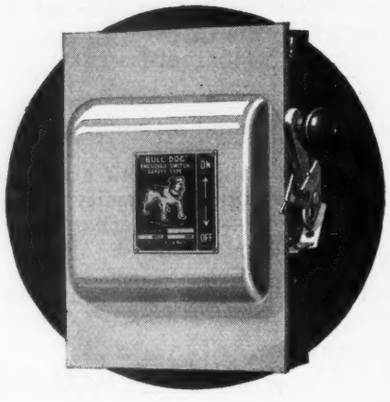
The "LUMINIZED" Bull Dog Safety Switch

This actual, unretouched photograph shows graphically the greater luminosity of "Luminized" Bull Dog Safety Switches as compared with the ordinary black finished switch. The picture tells the whole story.

The "Luminized" process makes the Bull Dog Safety Switch luminous in the dimmest light. Its attractive appearance harmonizes with the spick and span appearance of white basements and daylight factories. This luminous finish is applied by our own process, involving the depositing of aluminum flakes under high temperature.

The "Luminized" finish is not only clean-looking but stays clean. It is durable; resists rust, acids and alkalies; and permits a direct ground for wire or fitting. This greatest improvement of all has been added to the many quality features of Bull Dog Safety Switches without increase in price.

Descriptive circular and other information will be sent on request. Our engineers will gladly work with you on all matters pertaining to electrical control and distribution. Write for full details.



Some features of Bull Dog Safety Switches are: Quick Make — Quick Break; Heavy Substantial Construction; Superior Insulation—Simple—Dependable —Greatest Value.

MUTUAL ELECTRIC AND MACHINE COMPANY
Detroit Mich., U. S. A.

BULL DOG
SAFETY SWITCHES
SWITCHBOARDS-PANELBOARDS-CABINETS

Here is
Genuine Proof!!
NEARLY everybody knows that brass is made of copper and zinc, alloyed together under an intense heat—much in the same manner as the permanent zinc coat of Sherarduct is alloyed with the steel pipe. To prove the point, this copper disc was placed in a Sherardizing furnace and put through the same treatment as Sherarduct. The zinc coating is alloyed with the copper, as you will note by the brass that formed between the copper and zinc.
Convincing evidence, isn't it, that Sherarduct is rust-proof; that the zinc coat of Sherarduct will not rub off, crack or peel; that Sherardizing really alloys the zinc with the spelterized steel pipe of which Sherarduct is made. Besides, the intense heat through which Sherarduct passes anneals the pipe and makes it easier to bend on the job.
National
Metal Molding Co.
Pittsburgh, Pa.
World's largest manufacturers of Electrical Conduits and Fittings

See for yourself how Sherardizing alloys!

Pocket Evidence---Free

WHEN the proper metals meet and mix there is created new strength, new power of resistance—to rust, to corrosion, to time itself.

On the steel pipe of **Sherarduct** the heavy covering becomes an inseparable part of the conduit. **Sherardizing** alloys the metals. See the point of fusion in the free pocket token, how the copper and zinc unite and form brass. The zinc coating of **Sherarduct** is a part of the conduit—inseparable, irremovable. Ductile, rustless **Sherarduct** makes any conduit job a better job.

¶ *Send the convenient coupon—see for yourself how* **Sherardizing** *alloys with the steel pipe*

National Products

NATIONAL RIGID CONDUIT
For high grade wiring

SHERARDUCT — *Protected by both zinc and enamel*
ECONOMY — *Protected by enamel only*

FLEXSTEEL ARMORED CABLE and CONDUIT
For high class work at minimum cost

FLEXTUBE NON-METALLIC CONDUIT
For knob and tube wiring and the like

NATIONAL METAL MOLDING and FITTINGS
For circuit extensions and surface wiring

NATIONAL INSULATING BRACKETS
For service entrances and similar uses

NATIONAL CONDUIT and CABLE FITTINGS
Locknuts—Bushings—Box connectors and other items

NATIONAL OUTLET BOXES
a box or cover for every need

LIBERTY WIRES, CABLES and CORDS
For 600 volts or less

LIBERTY AUTOMOBILE WIRE
AUTO-STEELFLEX METAL CONDUIT
For the electrical circuits of motor vehicles

NATIONAL CARBURETER, HEATER and EXHAUST TUBING
For motor vehicles

National Metal Molding Company

WORLD'S LARGEST PRODUCERS OF ELECTRICAL CONDUITS AND FITTINGS

1076 Fulton Building, Pittsburgh, Pa.

Represented in All Principal Cities [14]

Sherarduct

The Rigid Conduit That Bends

SIGN—TEAR OFF AND MAIL TODAY

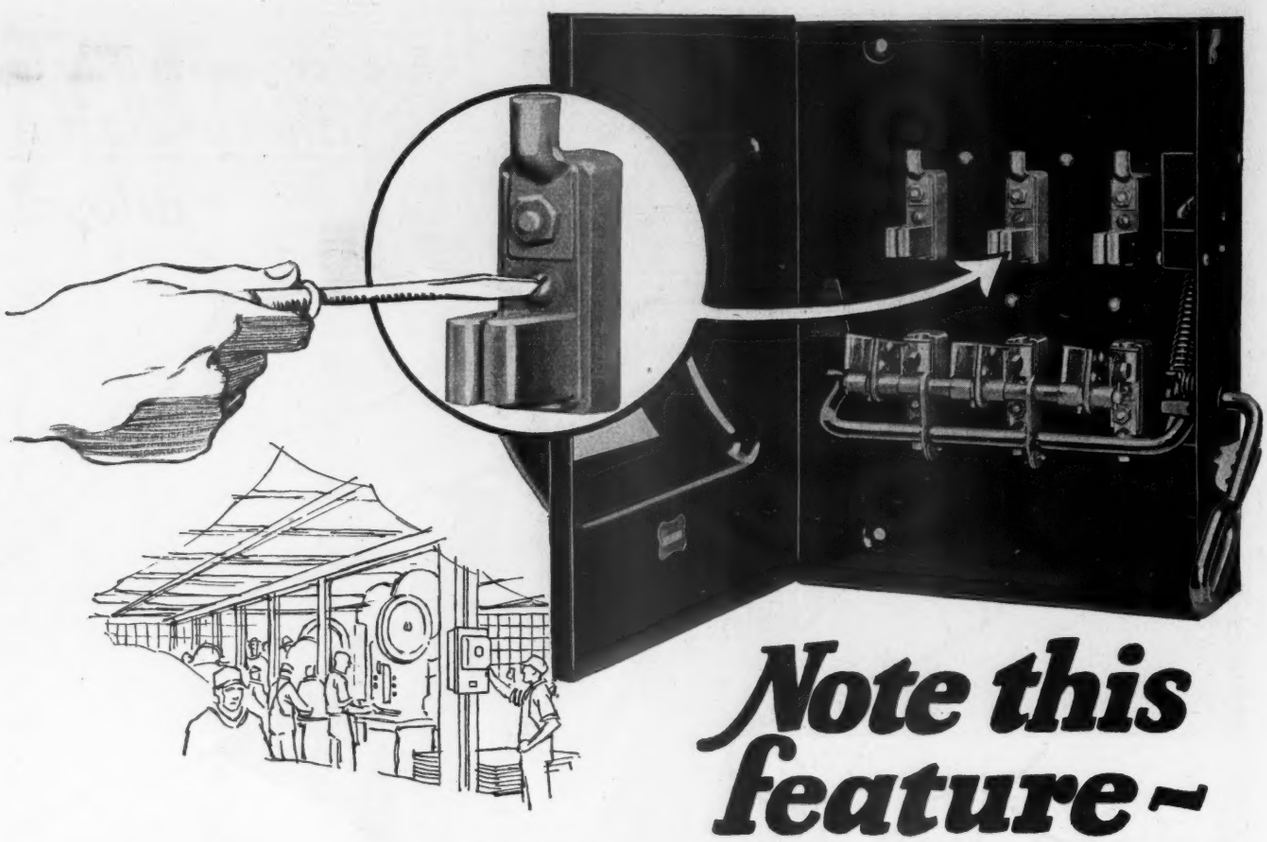
National Metal Molding Company
Pittsburgh, Pa.

Please send free pocket token demonstrating the results of **Sherardizing.**

_____
Name

_____
Firm

_____
Address



Note this feature –

Any Square D Part Quickly Removed or Replaced

Ease of maintenance is an outstanding feature of Square D Safety Switches.

All current-carrying parts are mounted on individual bases of tough, moulded insulating material. Any switch part can be replaced in a few minutes without removing the base from the box or disconnecting all wires.

The Square D individual bases have no metallic veins, withstand hard usage, and are very light in weight.

Add to this important feature assured safety, key-controlled accessibility, positive quick make and break action, enclosed mechanism, ease of assembly and adjustment.

These are among the things that have given Square D its dominating position and have made Square D standard for years in major industries.

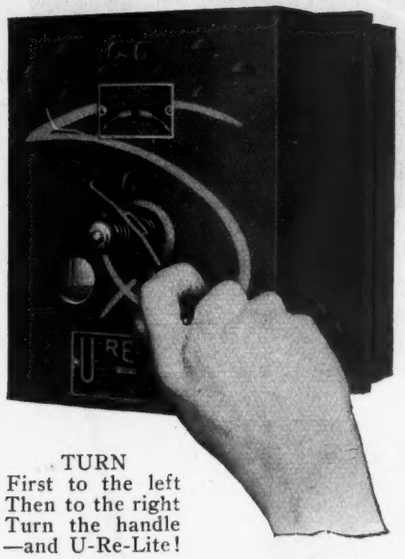
We invite your personal inspection of Square D advantages. Ask your jobber, or write us direct.

SQUARE D COMPANY, DETROIT, U.S.A.
FACTORIES AT: DETROIT, MICH., PERU, IND. (66)
BRANCH OFFICES: Boston, Buffalo, Chicago, New York, Pittsburgh, St. Louis, Philadelphia, Cincinnati, Milwaukee, Atlanta, Cleveland, San Francisco, Los Angeles, Syracuse, Kansas City, New Orleans, Baltimore, Columbus, Minneapolis, Indianapolis
SQUARE D COMPANY, CANADA, LTD., WALKERVILLE, ONT.
BRANCH OFFICES: Toronto, Montreal

SQUARE D
Safety Switch

PROTECTION

for your electrical equipment



TURN
First to the left
Then to the right
Turn the handle
—and U-Re-Lite!

Safeguarding electric motors, power and lighting circuits, against overloads and "shorts" is of such prime importance that only the best protection is good enough. Inadequate protection may mean a fire or the destruction of costly equipment.

U-RE-LITE

has for over five years given to industry this vital protection.

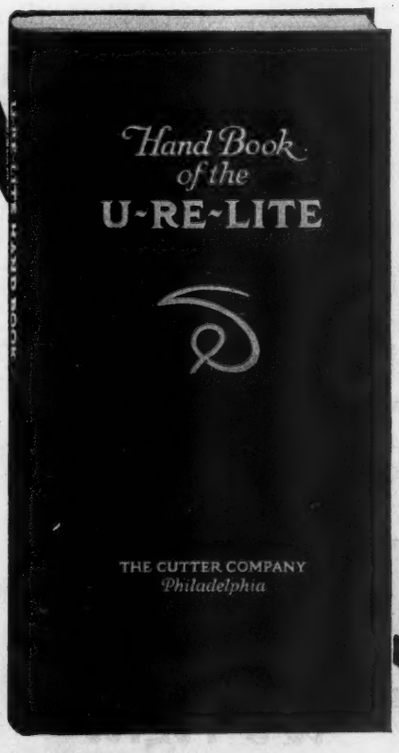
"The I-T-E Circuit Breaker in the Steel Box"

possesses a certainty of operation which puts it in a class by itself. When an overload or "short" occurs in a circuit protected by a U-RE-LITE, it merely opens the line. To restore service, simply turn the handle on the FRONT of the box.

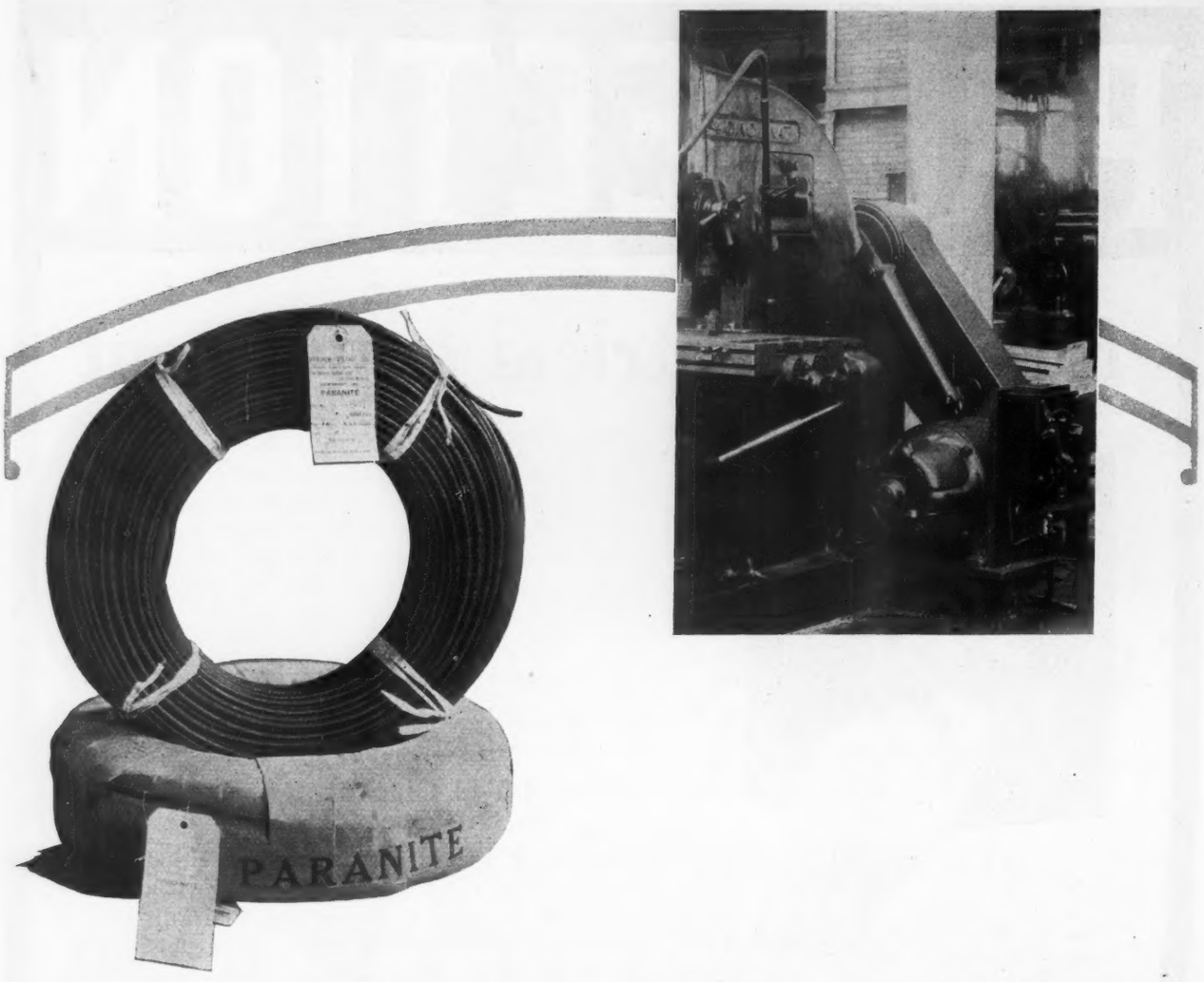
First to the left, then to the right,
Turn the handle, and U-RE-LITE.

Service is then resumed immediately, and what is even more important, this is accomplished without calling the electrician. YOU DO IT—YOU U-RE-LITE!

Write for HAND BOOK OF THE U-RE-LITE, just off the press. Sent free upon request.



The I-T-E CUTTER COMPANY
ESTABLISHED 1888 PHILADELPHIA
1824 Hamilton Street



How good is your wire?

That's a question of course that time will determine, but such being the case why place yourself in a position of doubt. You have a right to be sure about your wire and cable, at the start. You have a right to expect liberal service from your wire and cable. Therefore when we tell you that PARANITE will give you the fullest measure of value, all things considered, we are merely quoting in words, that which is happening in service wherever PARANITE is used.

Try PARANITE and see what "More than Code requires" can mean to you. The thick coat of extra quality rubber insulation is another reason for PARANITE superiority. PARANITE is easy to use—smooth and flexible.

Indiana Rubber & Insulated Wire Co.

Jonesboro, Indiana

CHICAGO OFFICE-Marquette Bldg., Room 811

NEW YORK - The Thomas & Betts Co., 63 Vesey St.

If it's

PARANITE

it's right

first

FIRST TO USE

self-aligning armatures with double shading coils

SEVEN years ago, self-aligning armatures with double shading coils were introduced on Westinghouse a-c. controller contactors.

As a result, noise, vibration, and wear were reduced to a minimum; armature life was appreciably increased; satisfactory contactor operation was assured; and special fitting of parts was no longer required.

Today, industry recognizes the Westinghouse a-c. self-aligning armature with double reducing coils as the most satisfactory design on the market. It is another standard part of all Westinghouse a-c. contactors materially contributing to the better operation of modern electrical equipment.

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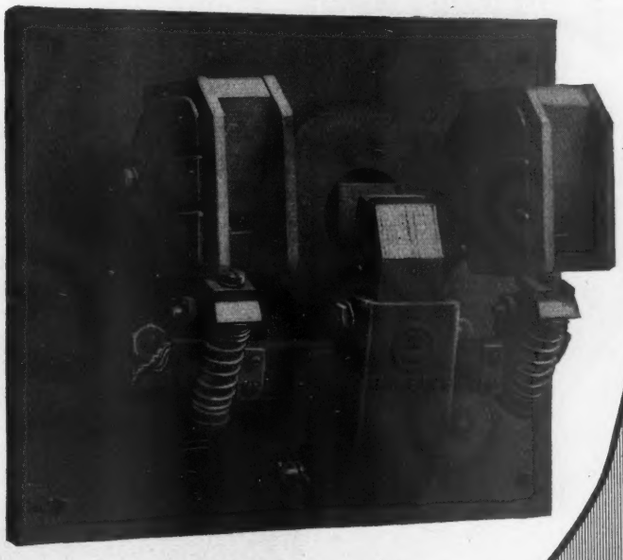
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of
the United States and Foreign Countries



The Westinghouse a-c. contactor with self-aligning armature and double shading coils

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WESTINGHOUSE ELECTRIC

Westinghouse

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Reduce Shut-Downs

with Westinghouse Automatic Switching Equipment

AFTER you have paid a lot of good money for motors and locomotives why keep them standing useless because of mistakes of carelessness resulting in needless shut-downs when using a manually operated board.

Automatic switching equipment can't make a mistake. It can't throw a running breaker in ahead of a starting breaker. It can't hold a starting breaker in until the coils of the auto transformer have been burned out. When the windings reach a dangerous temperature, it automatically shuts down the station until the danger is over. With automatic switching equipment a breaker can't be closed until the short circuit has been removed. Excessive heatings and overloads are taken care of automatically. Positive protection is always assured.

Replace the possibilities of human mistakes with mechanical certainty by specifying Westinghouse Automatic Switching Equipment for Substations.

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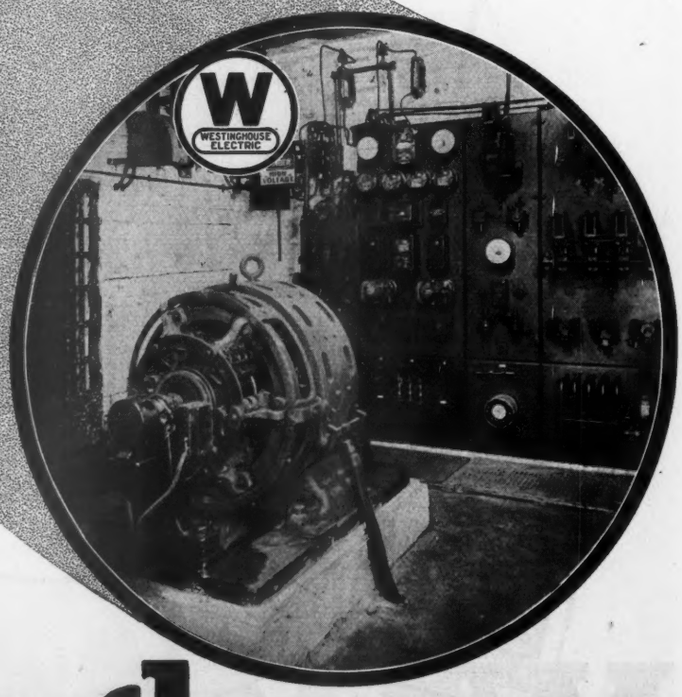
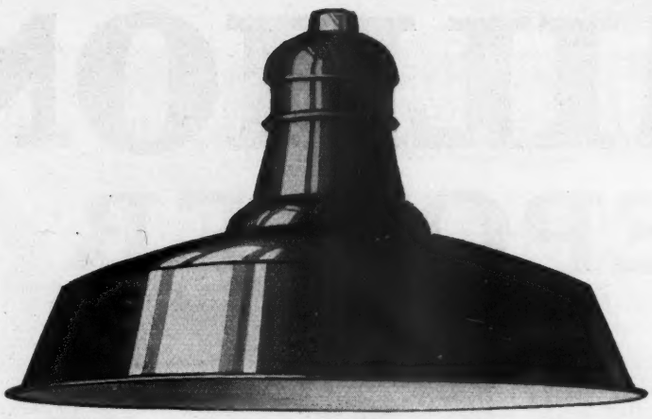
The solution—install Westinghouse automatic substations



Westinghouse



Just Suppose-

that you wanted to illuminate a machine shop in which the work performed is of medium grade—that is, there is no very fine work demanded. The floor space is 80 by 120 feet, and the ceiling is 12 feet high. The walls are tan and the ceiling is white. How many foot-candles would you specify? How many reflectors would you install? What type of reflector would you select? How would you space the lamps?

These are questions and problems that Westinghouse Engineers are answering and solving every day.

Westinghouse has a staff of trained illuminating engineers who are at all times ready to assist you. Take advantage of the knowledge of these engineers.

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W WESTINGHOUSE ELECTRIC

Westinghouse

12 MILLION HORSEPOWER proof

W WESTINGHOUSE ELECTRIC

Westinghouse has placed in operation electric motors aggregating more than 12 million horsepower.

These motors *must* have proved themselves, or else industry would not have installed more of them, in increasing numbers, year after year.

A LARGE percentage of this 12 million horsepower of Westinghouse Motors is still in service, playing its part in developing the 20 million horsepower of electric motors operating in the United States today.

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Westinghouse

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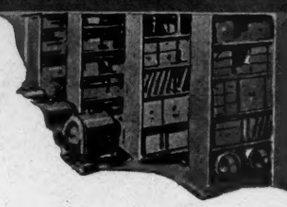
MAINTENANCE SERVICE, REPAIR PARTS, TOOLS AND SUPPLIES



In the maintenance departments of every industrial works and in every commercial electrical repair shop the range of the work that can be done and the dollar-savings that are possible depend on
(1) The ability and experience of the maintenance man.
(2) Adequate hand and bench tools and shop equipment.
(3) A well-balanced stock of spare units, parts, wiring supplies and raw material used in repair work.
Here then is a directory to the needs of the maintenance man under items (2) and (3) that he can use when he must have things in a hurry on an emergency job and when ordering for stock to meet his regular maintenance requirements.

Electrahot

Soldering IRONS

Here is an all-round electric soldering iron for a thousand and one industrial uses. It operates from an ordinary lighting circuit. Includes 6 ft. cord and 2-piece plug. Also made with 3/8" point for fine work.

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HARD MAPLE WOOD ARMATURE WEDGES

Cut from thoroughly seasoned and dried, straight grained, first grade maple stock, they will not warp or twist. Cheapest in first cost and effect further economy in assembling. Standard lengths of 30 in. Carefully wrapped with gummed paper, making a neat and compact bundle to handle with practically no waste in cutting to the required length.

The following jobbers keep a good stock on hand at all times:

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Western Insulation Co., 557 W. Monroe Street, Chicago, Ill.
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THE JAS. P. CRAFTS MFG. CO.
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Self-Lubricating Carbon Brushes

GUARANTEED TO CARRY THE GREATEST LOAD WITHOUT SPARKING, HEATING OR CUTTING OF COMMUTATOR. SPECIAL GRADES FOR EVERY SERVICE.

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PRACTICAL PULLING TOOLS
—that fill an every-day need

The "Little Giant" and the "Big Buster" cover a range of work which is not approached by any other combination of pulling tools on the market. These tools cannot spread, turn or slip off the work; no arm locks required.

"THE HARDER THE PULL—THE TIGHTER THE GRIP"

A principle quickly understood and appreciated by mechanics who have had experience with ordinary pullers.
"Little Giant" and "Big Buster" will easily and quickly pull commutators, wheels, pulleys, gears, pinions, bearings or anything with a tight fit or that is hard to get at with ordinary tools.
The "Little Giant" is the only Puller permitting adjustments of one or more arms to different lengths for uneven inside or outside pulls. This Tool has FOUR arms.

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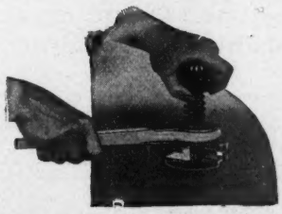
"JIFFY" CUTTER



Cuts clean, round holes thru steel boxes, slate and marble switchboard panels.

Five convenient sizes.

Adjustable Diameter 3/4" to 6". Easily used in cramped positions. Weight five pounds.

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PRICE $7.00
Extra Blades any size 25c per pair F. O. B. New York

Will Strip 1200 Ends an Hour

Regularly equipped, unless otherwise specified, with 3-hole stripper blades, Nos. 12, 16 and 18 gauge. Single-hole blades, ranging from 10 to 20 in even numbers, also supplied when specified.

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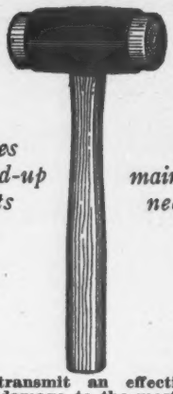

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A maintenance necessity

Will transmit an effective blow without damage to the most delicate surface.
But the blow is not more destructive to the tool itself than to the object to which it is applied—therefore, doubly economical.

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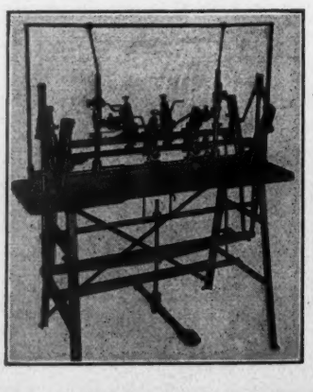

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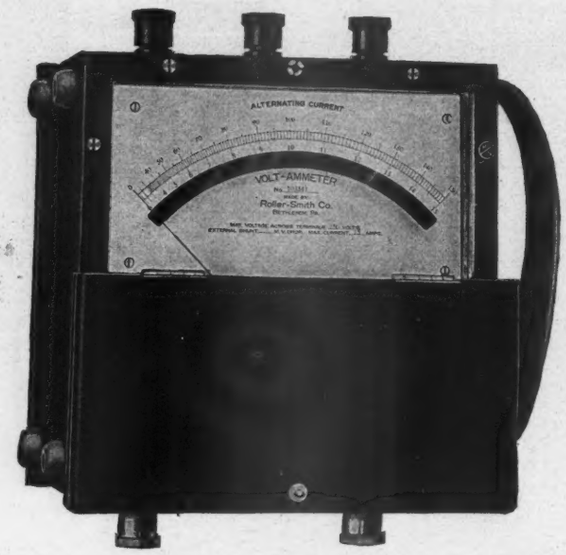
Roller-Smith takes particular pride in presenting its latest contribution to the instrument art—*a combination volt-ammeter for alternating current.* Convenient size, light weight, rugged and— above all—accurate and reliable.



The Type GSA Volt-ammeter and other Type GSA instruments are fully described and listed in Bulletin A-160.

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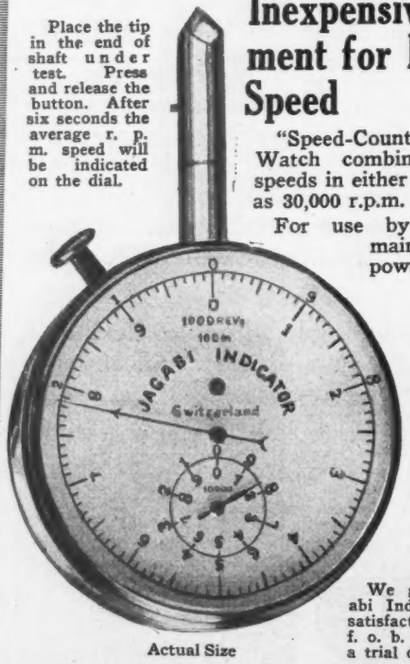
Place the tip in the end of shaft under test. Press and release the button. After six seconds the average r. p. m. speed will be indicated on the dial.



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"Speed-Counter" and Stop Watch combined in one for speeds in either direction as high as 30,000 r.p.m.

For use by engineers and maintenance men in power plants, mills and factories, wherever speed is to be measured. Is well made, meets commercial demands for accuracy and is thoroughly reliable for all-around service. A neat pocket case (4¾x3¼x1¼ inches) is provided.

We guarantee the Jagabi Indicator to give you satisfaction. Price $34 f. o. b. Philadelphia. Send a trial order.

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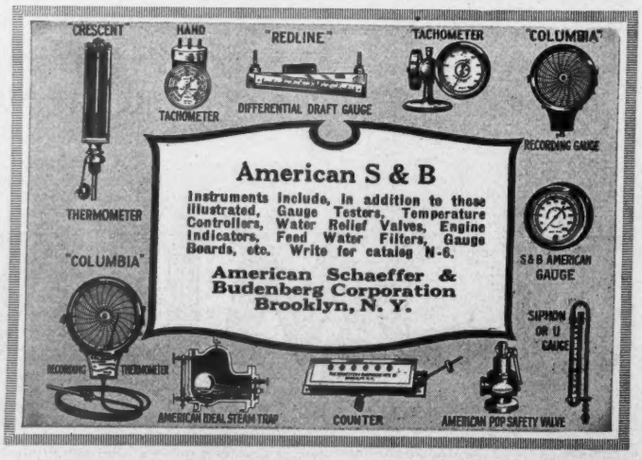

American S & B

Instruments include, in addition to those illustrated, Gauge Testers, Temperature Controllers, Water Relief Valves, Engine Indicators, Feed Water Filters, Gauge Boards, etc. Write for catalog N-6.

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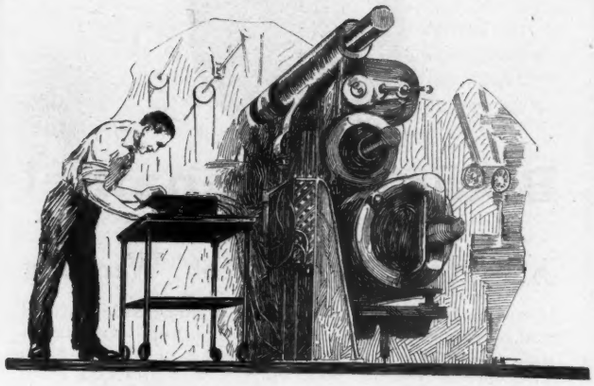

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Weston, Jr. instruments enable you to make almost any test required. When used with Model 461 Weston Universal Portable Current Transformer, Weston, Jr. Wattmeters and Ammeters may be used on circuits up to 800 amperes capacity.

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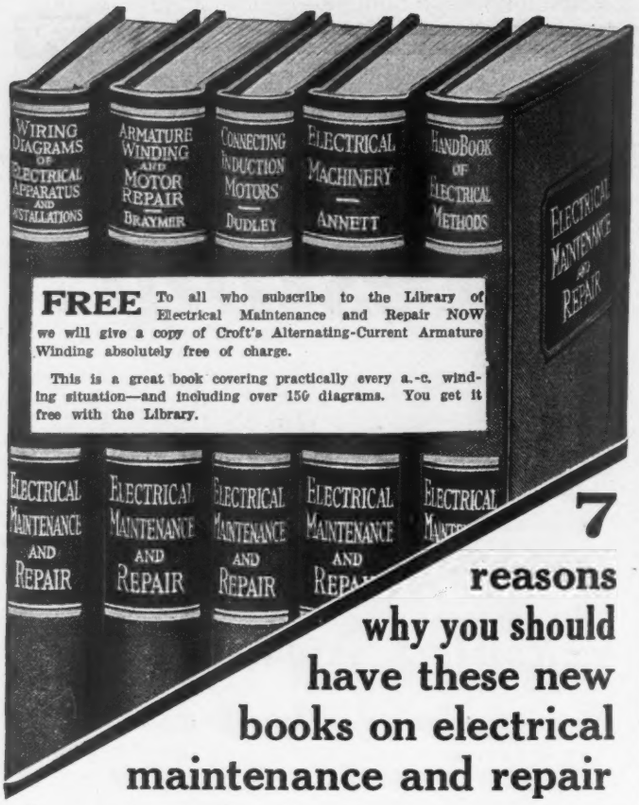
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Requires less space than double cotton insulation and makes fast, neat work easier. Cotenamel withstands oils and moisture. Does not open at sharp turns. Tests prove Belden Cotenamel is better dielectric than double cotton. Use Cotenamel on your next rewinding job. One trial will convince you.

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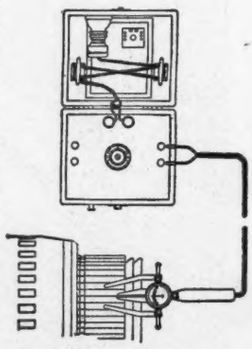
The Century Armature Tester is a quick and certain detector of faults in armatures. It instantly detects and exactly locates shorts, opens, wrong connections, and grounds, without unsoldering any of the lead wires from the commutator or disturbing the hoods. It is adapted for use with either alternating or direct current, or with a battery when power circuits are not available. It is supplied with both Receiver and Meter types of testing forks and ground detector. Write for descriptive folder and prices.



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Manufacturers of Armature and Field Coil Testing Apparatus.

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OUR LATEST TYPES OF PIPE AND TUBING BENDERS

Made expressly to bend pipe and tubing to small radii. Note what can be done on our TYPE No. 02.

Outside Diameter	Smallest Radii
½"	2"
⅝"	2¼"
¾"	2½"
⅞"	3"
1"	3½"
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We make twelve other types and sizes. Check up your work with what our machines will do. Write us your requirements. Send for catalogue and price list.

AMERICAN PIPE BENDING MACHINE CO.

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4 Years' Record Shows Its Proved Efficiency and Dependability

After several days' try-out, one recent purchaser of a Hullhorst Portable Undercutter said —*"the extremely small diameter of your cutter makes it very easy to guide, compared with other machines using large diameter cutters."*

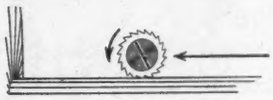
Another owner stated—*"we have used several undercutters, but yours is the first efficient machine we have found."*

This Portable Undercutter *reduces* the cost of undercutting to a low minimum. A 12-inch commutator is easily undercut, to a uniform depth in 30 to 50 minutes—at *minimum tool cost.*

It has a strong flexible shaft; a spindle of superfine precision work; end of arbor is supported by an outbearing; is equipped with motor, and a small fan that clears path of cutter for accurate guiding. It undercuts armatures up to 32 inches in diameter.

Four years' record of proved dependability supports our claims. A few days' trial would convince you. We *guarantee satisfaction.* Write for complete description.

The Hullhorst Micro Tool Co.
TOLEDO, OHIO

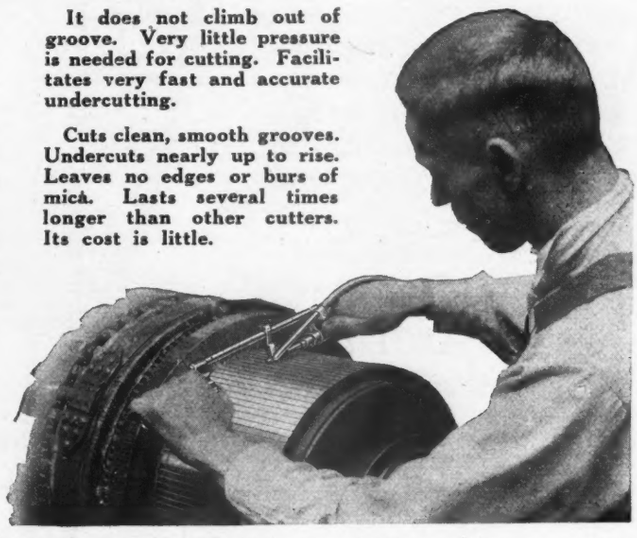


EXACT SIZE of Hullhorst Disc Mica Cutter

THIS SMALL DISC MICA CUTTER HAS IMPORTANT ADVANTAGES—

It does not climb out of groove. Very little pressure is needed for cutting. Facilitates very fast and accurate undercutting.

Cuts clean, smooth grooves. Undercuts nearly up to rise. Leaves no edges or burs of mica. Lasts several times longer than other cutters. Its cost is little.

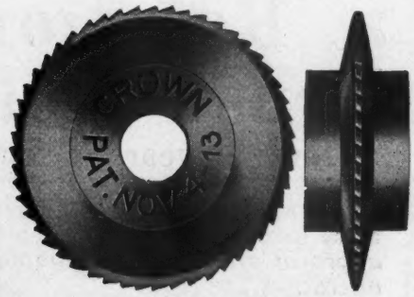


CROWN Pipe Tools

"Better than Standard"

Crown Three Wheel Barnes pattern pipe cutters are the strongest three wheel cutters made.

Crown Patented, Diagonally Serrated Pipe Cutting Wheels, will cut easily and outlast the ordinary type of wheel. Made to fit Crown or any standard pipe cutters.

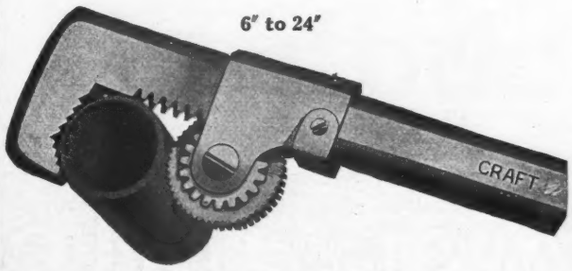


CROWN
Die and Tool Co.
2634 N. Keeler Ave.
Chicago, Ill.

Send for Catalog

The New CRAFT Pipe Wrench

6″ to 24″



A Sound Principle

Properly developed with the aid of the finest materials. These features entitle the CRAFT to the consideration of every mechanic:—

SPEED:——Entirely self-adjusting. May be applied or disengaged with one hand.

STRENGTH:——Bearing parts are tool steel—Handle cold-rolled steel, case-hardened.

DURABILITY:—The lower jaw presents a fresh bearing surface to each size of pipe and may be revolved as the teeth wear, allowing the use of its entire circumference and furnishing the equivalent of 10 ordinary lower jaws.

Ask your jobber or write us

PITTSBURGH MALLEABLE IRON COMPANY
Wrench Department
30 CHURCH STREET NEW YORK, N. Y.

Selma

Selma is the smoking and snuff kit of the Kaffir —he carries it with him always.

"But how?"—you ask—"since he has no clothes suitable for pockets."

"Easy!"—we reply, for in his youth the lobes of his ears are pierced and stretched for that purpose.

And the only moral we see in this is that it is never too soon to make provision for a demand that is sure to come.

Your machines may be operating without much trouble now—but peak demand will surely come —and it is then you'll want troubleless commutation—and the one sure way to get it is with a certain top-grade brush—the name of which you can get from any of the addresses below:

Morganite Brush Co., Inc.

Main Office and Factory:
519 West 38th St., New York

DISTRICT ENGINEERS AND AGENTS:

Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn. Ave.
Cincinnati, Electrical Engineering & Mfg. Co., 607 Mercantile Library Building.
Cleveland, Electrical Engineering & Mfg. Co., 422 Union Building.
Philadelphia, Electric Power Equipment Corp., 412 North 18th St.
Baltimore, O. T. Hall, Sales Engineer, 1926 Edmondson Ave.
Revere, Mass., J. F. Drummey, 75 Pleasant St.
Los Angeles, Special Service Sales Co., 502 Delta Building.
San Francisco, Special Service Sales Co., 202 Russ Building.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 131 Eastern Ave.
Montreal, Can., Railway & Power Engineering Corp., Ltd., 326 Craig St., West.
Winnipeg, Can., Railway & Power Engineering Corp., Ltd., P. O. Box No. 35.

You're having brush trouble

CORRECT IT
USE LE CARBONE CARBON BRUSHES

They talk for themselves

COST MORE PER BRUSH
COST LESS PER KW.H.

W. J. JEANDRON
343 Madison Avenue, New York

Pittsburgh Office: 634 Wabash Bldg.
San Francisco Office: 525 Market Street
Chicago Office: 1657 Monadnock Block

Canadian Distributors: Lyman Tube & Supply Co., Ltd. Montreal and Toronto

Do your **COMMUTATORS** run **HOT?**
Do you have **DESTRUCTIVE SPARKING?**
Are your **BRUSHES** wearing **GROOVES?**
Are your **MACHINES NOISY?**

Eliminate all these troubles and
Prolong the **Life** of Machines
by equipping them with

The original and improved

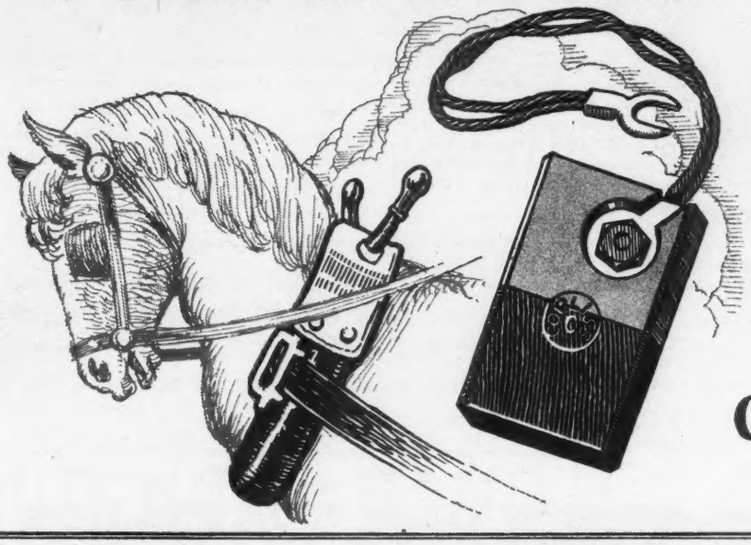
Reaction Brush Holder

over 20 years in service

Let us equip a Generator or Motor for ***you.*** Make its ***final acceptance*** subject to your ***approval after any reasonable period of operation.***

THE BAYLIS CO.
50 Nelson Street
BLOOMFIELD, N. J.

Horse Collars and Carbon Brushes



Horse collars are fitted to a horse by someone who knows how. It is not only humane to do so but it increases the *Horse Power.* Carbon brushes, like horse collars, are the connecting link between the power and the load. Fit your motors and generators with Corliss high grade brushes to increase efficiency and life and decrease cost.

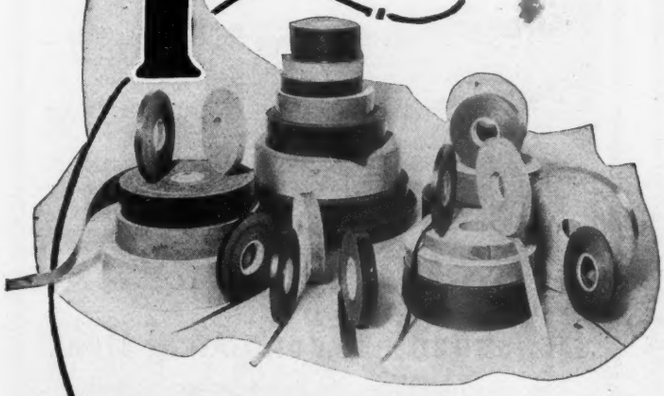
CORLISS · CARBON · CO.
BRADFORD, PA.
Send for booklet ~ 7-A

DISTRIBUTORS

Electrical Specialty Co.
Los Angeles - San Francisco - Seattle

The Beckett Electric Co.
Dallas - New Orleans - Monterey

IRVINGTON VARNISHED Cambric



Seven factors of Quality

High Dielectric Strength
High Resistance
Flexibility
Non-Hygroscopic
Heat Resisting
Chemically Neutral
Maximum Elasticity

Have you made temporary repairs in the past? The difference between making permanent and temporary repairs on motors, transformers, cable joints, coils, etc., has in many instances depended upon the quality of varnished insulation used. If an inferior grade of insulation is used—it soon fails—and the repair is a temporary one.

Make all your repairs permanent ones by insisting on Irvington Varnished Cambric. In many cases, it is good for the life of the equipment.

It has stood and will stand the test of time. And the test of time is the only real test for insulation. Ask our sales representatives for sample and prices.

IRVINGTON VARNISH & INSULATOR CO.
Irvington, New Jersey.

Established 1905

Sales Representatives:

Mitchell-Rand Mfg. Co. New York
T. C. White Electrical Supply Co., St. Louis
E. M. Wolcott, Rochester
Prehler Brothers, Chicago
Consumers Rubber Co., Cleveland
Clapp & Lamoree, Los Angeles and San Francisco
F. G. Scofield, Toronto

Could You Sell INSULATING VARNISH?

No charge is made for this valuable data book and catalog of insulations. All we ask is that you state on your request what company you are identified with—or ask for it on your company letterhead.

We want energetic dealers in every locality so as to make our products easily obtainable by those making or repairing electrical apparatus. The field is large—there is a prospective customer in every industrial plant, mine, street railway and power house.

Sterling Insulators are known the world over for their high standard of quality.

They have been marketed for many years by electrical engineers who understand the products and more particularly their application.

It is important that Sterling representation be on a par with Sterling service and Sterling products. We prefer dealers who are already handling lines allied with the insulation field. They must be in close touch with the shopman and should have a thorough knowledge of the shop's problems.

If you feel that you are thus equipped you will find the Sterling proposition interesting from both sales and good will standpoints.

Write for the handbook illustrated and get the Sterling sales proposition. We advise early action.

STERLING VARNISH
THE STERLING VARNISH COMPANY, PITTSBURGH, PA.

ELECTRIC Dolph's LACQUER

For your

DYNAMO — MOTOR — GENERATOR

Renews the Insulating Coating.
Prevents foreign substances from working into old insulation and open spaces in slots.
Protects against Dust, Acid Fumes, Moisture.

ABSOLUTELY OIL PROOF

Air Dries in Thirty Minutes.

Electric Lacquer is patented and the name is registered

Look for the name on the can

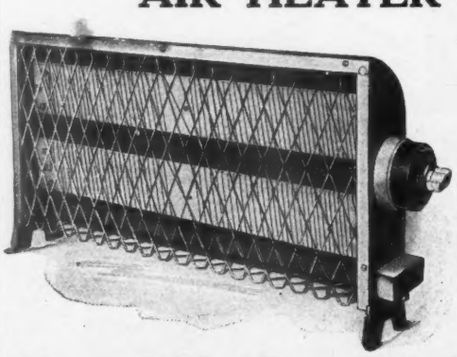
Accept this Offer Today

Send me a sample gallon of Dolph's Electric Lacquer and bill me @ $3.25 delivered. If for any reason this does not prove satisfactory after 30 days' trial I shall be pleased to accept your offer to refund the money.

Name .....
Address .....
Co. .....

JOHN C. DOLPH CO., 168 Emmet St., Newark, N. J.

DESPATCH
Circulating semi-reflecting type AIR HEATER



May be mounted on wall or floor

Five year guarantee on heating element

Dependable, Economical Heat

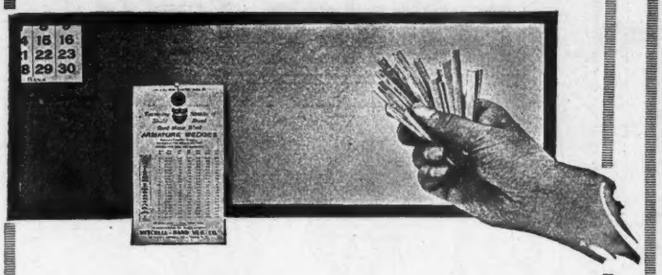
The effectiveness of this heater makes it highly desirable for heating isolated rooms, small buildings, factories, garages, mills, elevators, crane cabs, pumping stations, paint rooms, etc. Its design is such that it will heat a large volume of air and reflect it outward, obtaining maximum efficiency of the electricity used. Write and get details on this economical well constructed heater.

Manufactured and Guaranteed by

Despatch Manufacturing Company

Manufacturers of Electric Ovens and Heaters for all purposes.

116-122 First Avenue North
MINNEAPOLIS, MINN.



Unmounted samples enable the mechanic to determine, by actual test, size and style best suited for each job.

Seven and one-half miles of samples! To produce 9,000 sets of M-R Hard Maple Armature Wedges, each set comprising 21 styles 2½ inches long, over 8 linear miles of material was used.

MITCHELL-RAND

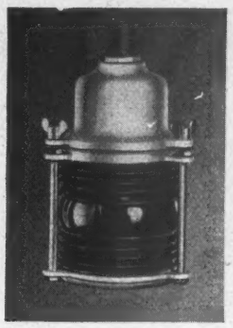
"Everything in Insulation"

Samples of M-R insulating materials—compounds, paints, varnishes, soldering paste, waxes, papers, cloths, twines, tapes, etc.—may be used as permanent indices of M-R quality; they are representative of the highest grades of merchandise.

You are invited to send for samples of any material used in your work.

MITCHELL-RAND MFG. CO.
20 Vesey Street **New York, N. Y.**

The "Eagle Eye" Signal Lantern



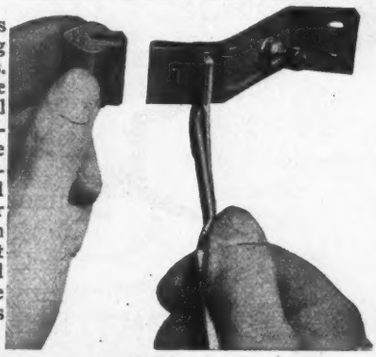
Six and a quarter inches high, this fellow, and less than two and a half pounds heavy. In lanterns, light weight and short life are generally synonymous, but not so with "Eagle Eye." Cast aluminum will stand weather, rough handling or acid atmospheres for many a day after less sturdy lanterns have passed on. This is a signal for countless warning jobs now being done ineffectively or not at all, and it will do them as they should be done—thoroughly and economically.

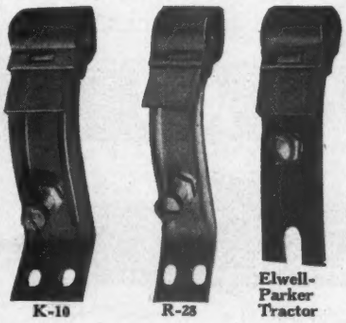
Write for complete details on "Eagle Eye," the boy who, with one bulb, sends a colored light all 'round him and a white light straight down.

THE NICHOLS-LINTERN CO.
7960 Lorain Ave. Cleveland, Ohio

Represented in Canada by Railway & Power Engineering Corp. Toronto, Ontario

This cut shows method of reversing or renewing tips. We furnish the tools. Each tip will outwear two ordinary fingers on one side; then it is reversed, giving equal wear on the other side. When both sides are worn out a new tip is snapped on the finger while the finger remains on the controller.





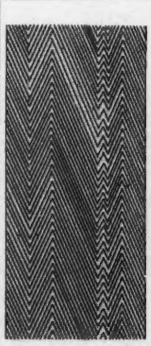
K-10 R-28 Elwell-Parker Tractor

With Trigger-lock Fingers on your controllers you renew only the tips and Save Money.

Trigger-lock fingers are made for all drum controllers, starters, cars, trucks, tractors, compensators, etc.

Our illustrated catalog shows the line. Write for a copy.

RUSSELL MANUFACTURING CO.
814 Bath Ave. **NIAGARA FALLS, N. Y.**
232 Westmount Drive **TORONTO, CANADA**



Standard Surgical Web .022 Inch Thick

IT PAYS TO *Awebco* **SPECIFY**

TRADE MARK REG. U.S. PAT. OFF.

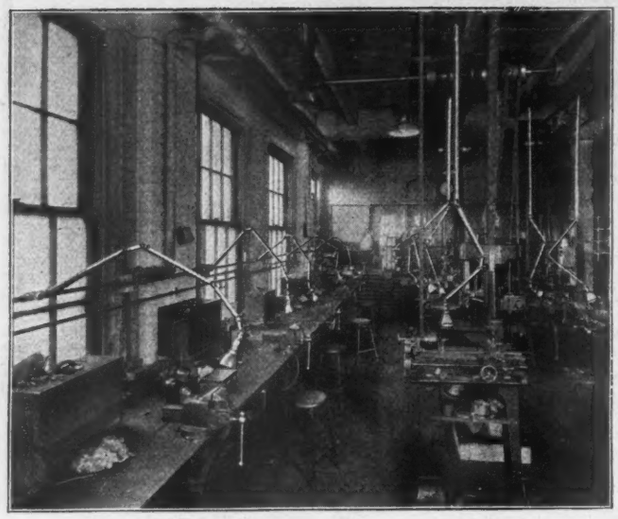
INSULATING TAPES

because repairs made with Awebco are lasting repairs.
The superior insulating qualities and long life of Awebco Tapes and Webbings insure lower maintenance cost.

Samples Free

Use our sample book as your guide in choosing suitable weights and styles of insulation tape.
Sample books sent on request.

Anchor Webbing Company
300 Brook Street, Pawtucket, Rhode Island
New York, Chicago, Cleveland, Pittsburgh, St. Louis, etc., etc.

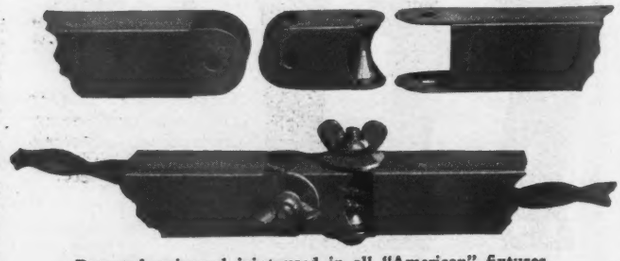


The Milwaukee Die Casting Company, whose shop is shown, have replaced previous bench and machine light with

"American"
Adjustable Fixtures *with* Conduit Fittings

Our catalog shows how numerous lengths and sizes are built up from standard parts.

This is a new development in American Fixtures, which makes possible better wiring, more substantial fixtures and more convenient arrangement. American Fixtures put the light directly on the work, eliminate eyestrain, fatigue and spoilage. They repay their cost many times over.



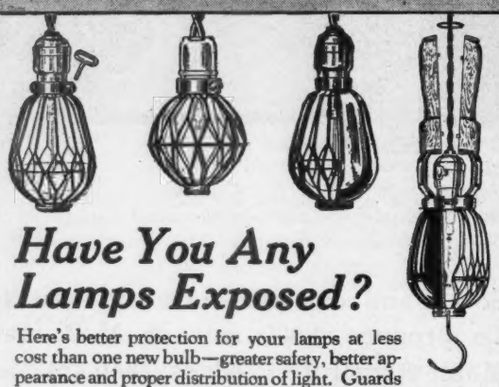
Patented universal joint used in all "American" fixtures. Permits unlimited adjustment and cannot injure the cord.

AMERICAN FIXTURE COMPANY

232 West Water Street
MILWAUKEE

Write for Catalog and Prices

FLEXCO-LOK



Have You Any Lamps Exposed?

Here's better protection for your lamps at less cost than one new bulb—greater safety, better appearance and proper distribution of light. Guards are reenforced expanded metal, heavy tin finish, hinged in base. FLEXCO-LOK is key locking and prevents unauthorized removal as well as accidental breakage. FLEXCO Guards close with slotted round head screws. One large plant saved 60% lamp replacements in a year.

Sample and prices on letterhead request.
Sold by leading dealers.

FLEXIBLE STEEL LACING COMPANY
4694 Lexington Street **Chicago, Illinois**

FLEXCO

TRADE MARK

The National Screw & Manufacturing Co.

(AB PRODUCTS DIVISION)

Cleveland, O.

Gentlemen:

IS YOUR PLANT DEAD?

It's only the dead industrial plants that aren't growing and changing constantly.

ABolite detachable reflectors, interchangeable with their respective holders, permit changing reflectors instantly to suit, and without disturbing the wiring.

Save your lighting installation from "growing pains."

Yours sincerely,

W. G. Rogoland

Sales Mgr. AB Div.

REFLECTORS

YOUR SAMPLE IS READY FOR YOU

Send today for a free sample of the

Levolier

Conduit Box Switch

6 Amp., 125 V.; 3 Amp., 250 V.
Examine the switch. Try it out on some lighting unit in workroom or office. See how easily it is installed and how satisfactory it is in operation.

Complete, ready to install. Each switch supplied with 6 feet of linen cord and composition ball.

Cat. No.	Stem Diam.	Stem Length	List Each
61	7/16 in.	3/16 in.	$0.55
*61S	7/16 in.	3/16 in.	.55
62	7/16 in.	3/8 in.	.60
63	7/16 in.	3/4 in.	.60

*For brackets and electrical appliances of all kinds where individual control is desired. Has plain lever without cord and ball.

Enjoy the Benefits of Individual Control

The new improved Levolier Conduit Box Switch gives individual control to lighting units. Easily installed, the switch will operate without trouble or attention indefinitely.

Approved Under the Underwriters' Laboratories New Specifications

Quick make and break contacts. Sure and positive in action. Has passed all full load endurance tests and the 50 per cent over-load test 100 per cent.

No running of extra conduit to the switch; no extra wiring when you install the Levolier Conduit Box Switch.

Make a test installation yourself.

Specify catalog number in writing for your sample and in ordering.

Levolier — Pull Sockets, Pull Hooks, Conduit Box, Fixture, Lever, Pull and In-Between Switches, Hickeys

McGILL MANUFACTURING CO.
Electrical Specialties of Quality
ESTABLISHED 1904
VALPARAISO · INDIANA

Lamp Guards, Lamp Cleaning and Frosting, Soldering Flux, Blow Torches, Lamp Changers

Patented Jan. 30, 1917

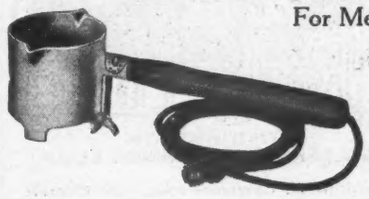
"Autex" Extension Reel

Rapidly finding a place in the largest industrial plants, machine shops, service stations, etc., in the U. S. Used for both electric lamp and power extensions.

Approved by Underwriters
Write for descriptive circular

The Cincinnati Specialty Mfg. Co., Inc.
Powers St. at Sylvan Ave. Cincinnati, Ohio

ELECTRICALLY HEATED POURING LADLE



For Melting and Pouring

Paraffin Wax
Battery Compound
Solder
Babbitt
Type Metal

Manufactured by

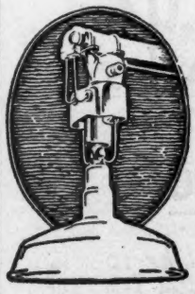
Justice — J S D — Service — Dependability

J. STRUTHERS DUNN
1109 Race St., Philadelphia, Pa.

The Lamp Cleaning Problem

is solved by the use of the

Thompson Safety Lowering Switch



—because it enables overhead lamps to be lowered away from the electric circuit for cleaning the reflectors or renewing bulbs.

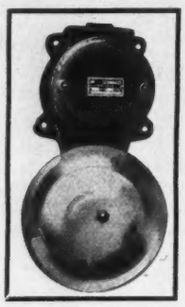
THE ADVANTAGE IS OBVIOUS

It is inexpensive and easily included in present installations. Illustrated booklet and complete information on request.

The Thompson Electric Company
226 St. Clair Ave. N. E. Cleveland, Ohio

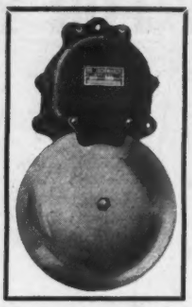
Weatherproof SCHWARZE Vibrating Bells

With Manual Trip Attachment



No. 6c D.C. Cyclone
No. 7c A.C. Cyclone

Nos. 76 and 77
A. C. Cyclone Bell



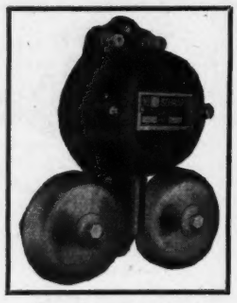
No. 6 D.C. Cyclone
No. 7 A.C. Cyclone

Full Protective Grid

No. 75
A. C. Cyclone

Transformer and High Voltage A.C.
Battery and High Voltage D.C.

Cyclone bells are approved by National Board of Fire Underwriters for Industrial Signalling. They are the most reliable bells for Fire Alarm and General Calls in your plant. Write factory or nearest branch office for catalogue and full particulars.



Nos. 9, 9A and 11
A. C. Polarized

Branch Offices:

Minneapolis, Minn. 915 Metropolitan Life Bldg.
Detroit, Mich. 1444 Park Place E.
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Cleveland, Ohio 452 Leader News Bldg.
St. Louis, Mo. 1415 Pine St.
San Francisco 515 Market St.
New York City 291 Broadway
Philadelphia, Pa. 481 Bourse Bldg.
Boston, Mass. 132 Pearl St.
Los Angeles 212 Calo Bldg.
Seattle, Wash. 222 Hinckley Bldg.

Main Office and Factory
Schwarze Electric Co., Adrian, Mich., U.S.A.

It's fame encircles the globe

for all Metals

Ruby-Fluid

COMBINATION SOLDERING AND TINNING FLUX

There is no better substitute for dangerous acids, Zinc Chloride, Sal Ammoniac and other mixtures misused as a Flux. It is quick acting, anti-rusting, non-poisonous and non-corrosive.

Free sample sent on request.

THE RUBY CHEMICAL CO.
68-70 McDowell St. Columbus, O.

PAINE STAR DRILLS

are made of the best grade of
CRUCIBLE TOOL STEEL
Oil finished—Head polished

Our specialized Heat Treatment produces the best there is in Tool Steel. Long *deep* flute. Elegant appearance.
FULLY GUARANTEED.
Write for discount. Our prices are right.
Send for Bulletin 900

THE PAINE COMPANY
2951 Carroll Avenue Chicago, Ill.
33 Warren Street New York City, N. Y.

ALLEN FLUX

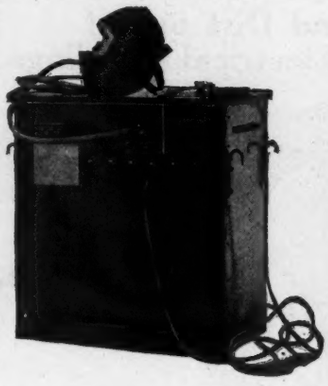
ALLEN NON ACID SODERING FLUX

Makes Sodering Jobs A Joy

Any Metal to any Metal
from
ALUMINUM to ZINC

Send for a free sample; you'll like it

L. B. ALLEN CO., INC.
4531 N. Lincoln St. CHICAGO, ILLINOIS



Left—200 ampere Allan Welding Transformer

Below—200 ampere Motor-Generator Set. (Also furnished with gas engine or belt drive)

The "ALMANC" ARC WELDING SETS

cover the entire field, consisting of arc welding transformers and generators of various capacities, also welding outfits for use on light cast iron sections such as automotive cylinder blocks and crank cases. Special machines constructed with combination of both arrangements when desired.

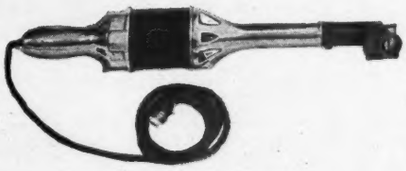
Advise us of your welding problems and current supply and we will recommend suitable machine for your requirements.

ALLAN MANUFACTURING & WELDING CO.
724 WASHINGTON ST., BUFFALO, N. Y.

Cut Maintenance Costs!

AURAND SLOTTER

Far superior to hack saw blade, file or scraping tool. Cuts time of undercutting, eliminates damage to commutator bars and does a better job.

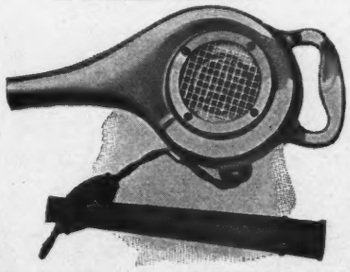


Acme Stones

For grinding and polishing commutators. May be used while machine is under load, avoiding shut-downs and production losses. Once the commutator is in true, Acme Stones will keep it in prime condition with an occasional treatment.

Emery 4 Cyclone Blower

For keeping dust and dirt from all manner of electrical and other equipment. Gives a strong blast of dry air. Eliminates danger of condensation in windings and will not disarrange fine meter adjustments.



Get full information on our liberal Free Trial Offer

Green Equipment Corporation
330 So. Dearborn St. Chicago, Ill.

CAUSES OF BRUSH AND COMMUTATOR TROUBLES	EFFECTS: Sparking	High Mica	Flat Spots	Commutator Heating	Armature Heating
1. Sparking		√	√	√	
1. Too low carrying capacity				√	
2. Too little abrasive action		√		√	
3. Too much abrasive action				√	
4. High friction brushes				√	
5. Too high contact drop	√			√	
6. Too low contact drop	√			√	√
1. Brushes off electrical neutral	√			√	
2. Incorrect brush spacing	√			√	√
3. Brushes too thick	√			√	√
4. Brush pressure too low	√	√		√	
5. Brush pressure too high				√	
6. Unequal brush pressure	√				
7. Brushes tight in holders	√	√	√		

Send for this *FREE*

Commutator Trouble Chart

This 10"x14" trouble chart showing all troubles and their causes sent Free on Request. Use convenient coupon below.

Use "IMPERIAL" COMMUTATOR STONES

Immediate delivery from Stock

Reason No. 10. Last, but not least—the handles will not come loose from Imperial Commutator Stones.

3118 users on November 1st, a gain of 65 for October.

"IMPERIAL" Commutator Cement

Here is a new Commutator Cement that is mixed, ready to use, and will keep several months without deterioration if the can is kept properly covered when not in use. Write for information.

The Martindale Electric Co.,
11709 Detroit Ave., Cleveland, O.

Without obligation on my part, please send me a copy of the Carbon Brush and Commutator Trouble Chart.

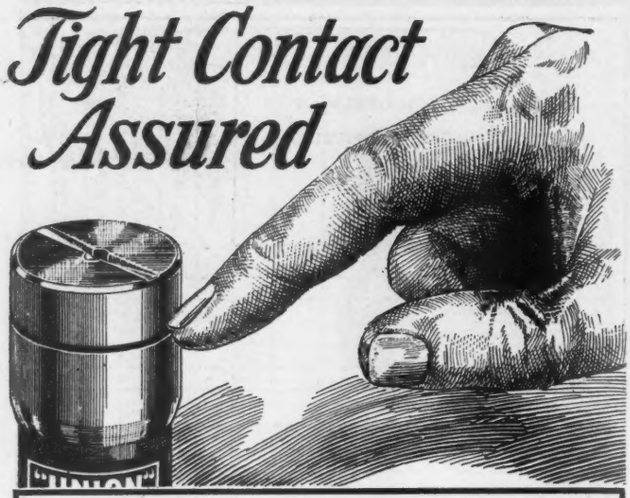
Name & Title.....
(Please Print)

Company.....

Street.....

City and State.....
12-24

Tight Contact Assured



Note the space between the cap and ferrule? That permits screwing the caps, link and washers up tight on the ferrules. It insures perfect contact and infallible performance.

The link cannot twist, as it is inserted through slots in washers that are held in position by means of dowels.

'UNION' RENEWABLE FUSES

contain more metal in the caps and ferrules than other makes. Heating of metal parts and charring of tube is thus reduced to a minimum.

Moreover, the "Union" Link blows without flash or violence, further reducing the liability of damage to tubing when fuse blows.

Every part is designed to give these fuses extra long life—to make them live up to our claim that

The "Union" Is a Good, Dependable Fuse

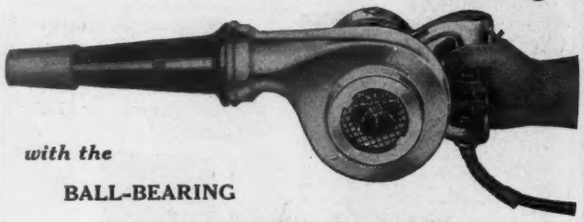
"Union" Renewable and Non-Renewable Fuses are sold by leading jobbers and dealers.

Interesting Catalog sent on request.

CHICAGO FUSE MFG. CO.
MANUFACTURERS OF
ELECTRICAL PROTECTING MATERIALS AND CONDUIT FITTINGS
LAFLIN & 19TH STREETS
CHICAGO

UNION
REG. U.S. PAT. OFF.

Keep Dust and Dirt out of Your Electrical Windings



with the

BALL-BEARING

CADILLAC
PORTABLE ELECTRIC BLOWER

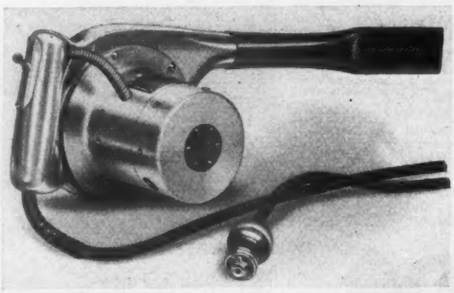
Plug in at the nearest light socket, press a switch, and blow the dust and dirt out of your motors, generators, etc., with a 150 mile an hour gale! That's all there is to keeping your electrical equipment clean with the CADILLAC Portable Electric Blower. No dangerous condensed moisture, as in compressed air. Correct pressure for cleaning thoroughly, yet without injury. No installation expense, negligible upkeep.

Can be converted into powerful suction cleaner for cleaning stock bins, etc.

Write for descriptive folder, giving prices, list of users, etc.

CLEMENTS MFG. CO.
617 Fulton Street **Chicago**
Canadian Factory: 76 Duchess St., Toronto
Export Department: 149 Broadway, New York

Ball Bearing Portable Blower



6½ lb. Air Cooled BALL BEARING Motor

$40.00 Net Retail

This "MARVEL" Portable Blower is designed for blowing dust and dirt out of MOTORS, GENERATORS, SWITCHBOARDS, LOOMS, KNITTING and other TEXTILE MACHINERY, as well as for GAS BLOW PIPES, GAS FURNACES, ETC. Has 20 feet high grade cable and armored plug. Perfectly balanced. Has TOGGLE SWITCH in handle, operated by thumb. Gives 16-inch water column pressure.

Note the Metal Conduit carrying wires from motor to handle.

Motor operates at 10,000 R.P.M. on New Departure BALL BEARINGS. This Blower is a great time and labor saver, and its mechanical and electrical design gives assurance of a very long life with a minimum of attention.

Made with UNIVERSAL motors (A.C. & D.C.) for both 110 volts and 220 volts. SHIPPING WEIGHT 18 lbs. Shipped on 10 days' trial, ANYWHERE.

Mention this advertisement

Manufactured by

ELECTRIC BLOWER COMPANY
352 Atlantic Avenue
Boston 9, Mass., U. S. A.

ILLUSTRATED are four subjects taken from the more important products of Cory. The Cory-Recony Standardized Unit System for the remote closing of inaccessible gate valves—the Robinson Interlock to protect men from opening disconnecting switches under load—the Cory Central Station Annunciator that warns the eye and the ear of trouble in any part of the plant and the Cory Visible Signal Systems for the instantaneous transmission of messages between important points in Industrial Plants.

Industrial Engineers are invited to visit the Cory Booth and watch these Systems in operation. A true perspective of Cory Service in the saving of life, equipment and time.

CHAS. CORY & SON Inc.

The World's Largest Manufacturer of Signaling, Communicating and Lighting Equipment

Cory Service

CORY SAFETY SERVICE TRADE MARK EST. 1849

New York	183 Varick Street
Philadelphia	The Bourse
San Franscisco	11 Mission Street
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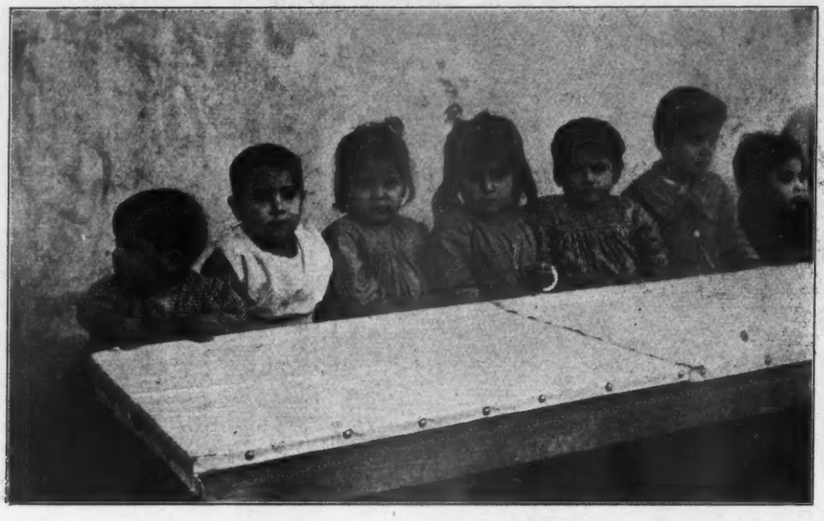
Representatives

Pittsburgh	Jno. D. Hiles, Oliver Bldg.
Seattle	W. S. De Pierris, 515 Hoge Bldg.



The Meal You Will Enjoy Most

—is the dinner that thousands of people the world over will eat on December 7th—"Golden Rule Sunday." It won't be a pretentious meal—just soup, bread, stewed fruit and cocoa. But it will give infinite satisfaction to the men and women who eat it. It will help them to put themselves in the places of thousands of children in the Near East who haven't even such simple food to eat. It will make these men and women thankful—it will make them remember the Golden Rule. They will give their contributions to buy food for the 100,000 hungry children in Greece, Syria, Palestine and Armenia—boys and girls who are fatherless, homeless and destitute.

You, too, can have the lasting joy that comes from a simple act of kindness—an observance of the Golden Rule—"Whatsoever ye would that men should do unto you, do ye even so to them." Every dollar that you contribute to the Near East Relief will buy twenty dinners of soup, bread, rice and cocoa for these Near East Orphans. One hundred dollars will feed, clothe and educate one of these children for a year.

Remittance Form For Use on Monday, December 8th

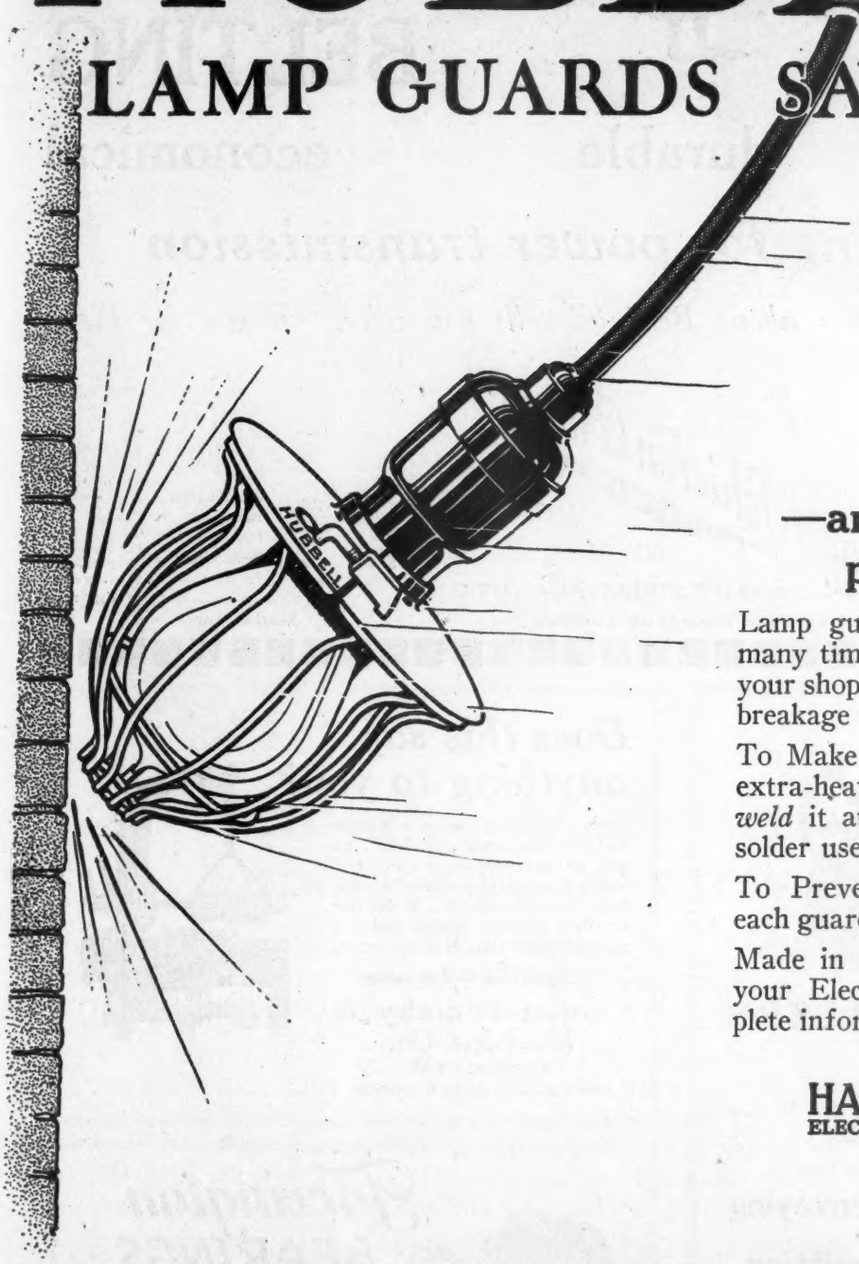
To **Cleveland H. Dodge, Treasurer,**
Near East Relief,
151 Fifth Avenue, New York City.

To help one of the orphaned children in your care, Noted in INDUSTRIAL ENGINEER, I enclose $.....

Name .....Address .....

HUBBELL

LAMP GUARDS SAVE LAMPS



—and one lamp saved pays for a guard

Lamp guard protection pays for itself many times over. See that the lamps in your shops are protected against theft and breakage with Hubbell Lamp Guards.

To Make Them Strong—we use No. 11 extra-heavy steel wire and *electrically weld* it at every intersecting point. No solder used.

To Prevent Rust—we thoroughly coat each guard with pure block tin.

Made in a wide variety of types. Ask your Electrical Supply House for complete information and prices.

HARVEY HUBBELL INC
ELECTRICAL WIRING DEVICES
BRIDGEPORT CONN. U.S.A.

No. 6995—Mill Type; for brass shell sockets.

No. 5691—all wire guard; for brass shell sockets.

No. 6650—locking lamp guard used with Parabola reflector.

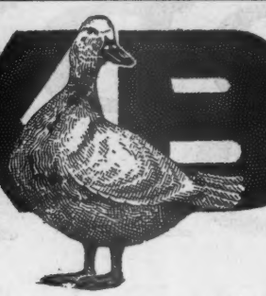
No. 5764—locking type; side reflector; for brass shell sockets.

No. 5685—locking type lamp guard; for brass shell sockets.

ELECTRICAL WIRING DEVICES HUBBELL

2476-U

DUXBAK



LEATHER BELTING

efficient durable economical

an ideal belting for power transmission

—our series of "Quality Facts about Belting" tells you why. Write for them.

DUXBAK BELTING TRADE MARK

Thoroughly Waterproofed and Built for Service

Chas. A. Schieren Company ESTABLISHED 1868

Tanners

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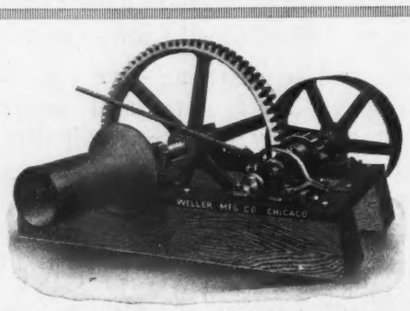

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Made in Several styles.
Direct Connected or Belt Driven.
Capacities 2 to 18 cars
Send for Car Puller Catalogue.

We Make a Complete Line of

Elevating, Conveying And Power Transmitting Machinery

WELLER MADE CHICAGO

Our engineers are at your service to help in the selection of equipment to meet the requirements. Submit your problem.

WELLER MFG. CO.

1820-1856 N. Kostner Ave. Chicago, Ill.

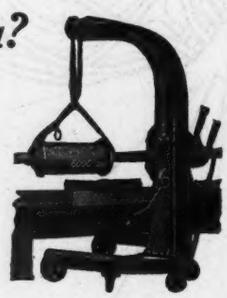
SALES OFFICES:

New York, Boston, Baltimore, Buffalo, Pittsburgh, Detroit, St. Louis, Omaha, Salt Lake City, San Francisco

Does this say anything to you?

If one man with the aid of a "Canton Portable Floor Crane and Hoist" can pick up and walk away with a two ton load, you will agree that a lot of time is saved by its use. It will pay for itself in a few months, and be a source of satisfaction to all concerned.

Write for Our Booklet Today



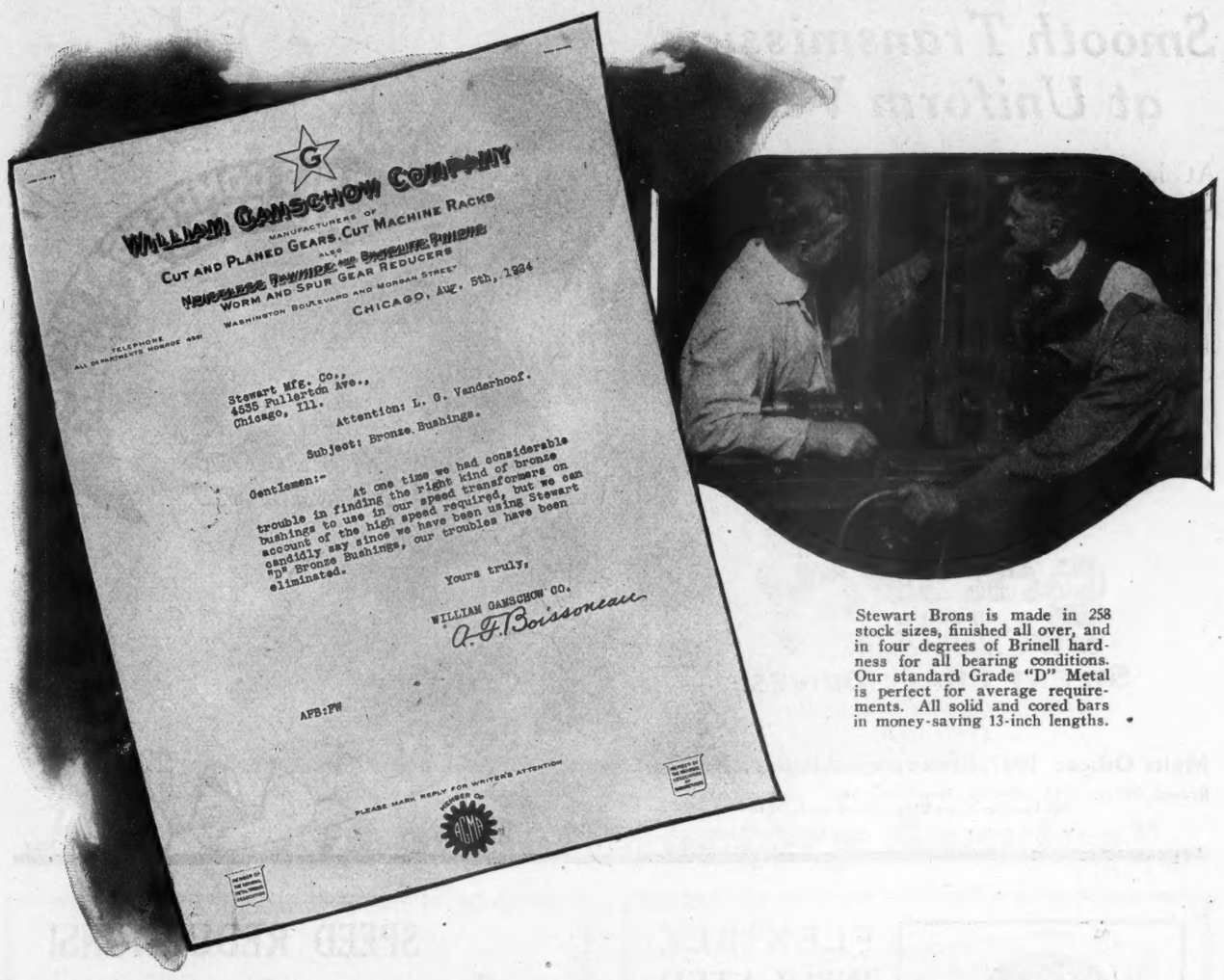
Canton Foundry & Machine Co.
Canton, Ohio
New York Office, 203 E. 15th St.

Torrington BEARINGS

Accurate
Dependable
Quiet

Samples or Specifications on Request

The Torrington Company
ESTABLISHED 1866
TORRINGTON, CONN., U.S.A.


WILLIAM GANSCHOW COMPANY
MANUFACTURERS OF
CUT AND PLANED GEARS, CUT MACHINE RACKS
ALSO
WORM AND SPUR GEAR REDUCERS
WASHINGTON BOULEVARD AND MORGAN STREET
CHICAGO, Aug. 5th, 1924
Stewart Mfg. Co.,
4535 Fullerton Ave.,
Chicago, Ill.
Attention: L. G. Vanderhoof.
Subject: Bronze Bushings.
Gentlemen:-
At one time we had considerable trouble in finding the right kind of bronze bushings to use in our speed transformers on account of the high speed required, but we can candidly say since we have been using Stewart sp* Bronze Bushings, our troubles have been eliminated.
Yours truly,
WILLIAM GANSCHOW CO.
A. F. Boissoneau
AFB:FW
PLEASE MARK REPLY FOR WRITER'S ATTENTION

Stewart Brons is made in 258 stock sizes, finished all over, and in four degrees of Brinell hardness for all bearing conditions. Our standard Grade "D" Metal is perfect for average requirements. All solid and cored bars in money-saving 13-inch lengths.

Remarkable Evidence of the Superiority of Stewart Brons

Here's bearing quality, the like of which was never known until Stewart Brons proved that the secret of the perfect amalgamation of copper and lead was discovered.

Stewart Brons provided remarkable bearing quality through an unusually low coefficient of friction. Its melting point is 1700° F.; remember that ordinary babbitt melts at 400° F. At 600° F. Stewart Brons sweats a little lead, lubricating itself should lubrication fail. It will not burn out or score a shaft up to 1000° F.

What bearing trouble do **you** want to eliminate? Send your blue prints. Our Engineering Department will give you the information you need.

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4509-92 FULLERTON AVENUE CHICAGO, ILLINOIS

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Stewart Brons Bearing Metal
The Perfect Metal for Bearings

Smooth Transmission at Uniform Velocity

At last! A smoother running, longer life Chain Drive, all due to that distinctively different and exclusively ***Ramsey*** feature —the ***Compensating Joint.***

Let us send you our highly interesting Text Book on Power Transmission, telling in a clear and convincing manner why the Ramsey Silent Chain Drive excels in the Power Transmission Field over other forms of drives—chain, leather, etc. It's free.

What's your name? Address?

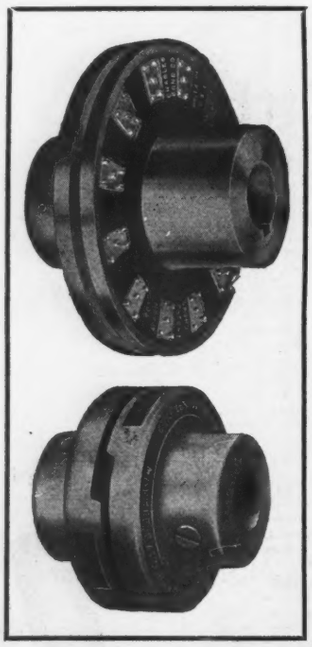
RAMSEY (RAMSEY) CHAIN CO. INC.

SILENT CHAIN DRIVES

WITH THE COMPENSATING JOINT (PATENTED)

Main Office: 1047 Broadway, Albany, N. Y.

Branch Offices: 41 E. 42nd St., New York City
855 Leader-News Bldg., Cleveland, Ohio



FLEXIBLE INSULATED COUPLINGS
(PATENTED)

that give you every advantage plus real service.

The GRUNDY

Here's a smoothly operating unit that will transmit more horsepower and give longer service than you have been accustomed to receiving. In addition to its efficiency, this coupling has no projections to cause damage.

The MATHER

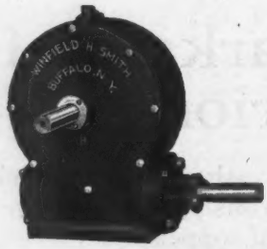
A little cross-shaped leather insert gives this coupling great flexibility. Has few parts and thus is free from ordinary coupling defects. It's a most desirable coupling for use in connection with small motors and light loads.

Ask for Booklet "F."

CHARLES Bond COMPANY

617-619 Arch Street **Philadelphia**

SPEED REDUCTIONS!



Why not connect direct to your motor? Eliminate cumbersome chains and countershafts.

Standard units carried in stock.

Reductions as large as 96 to 1.

Send for booklet No. 21.

WINFIELD H. SMITH

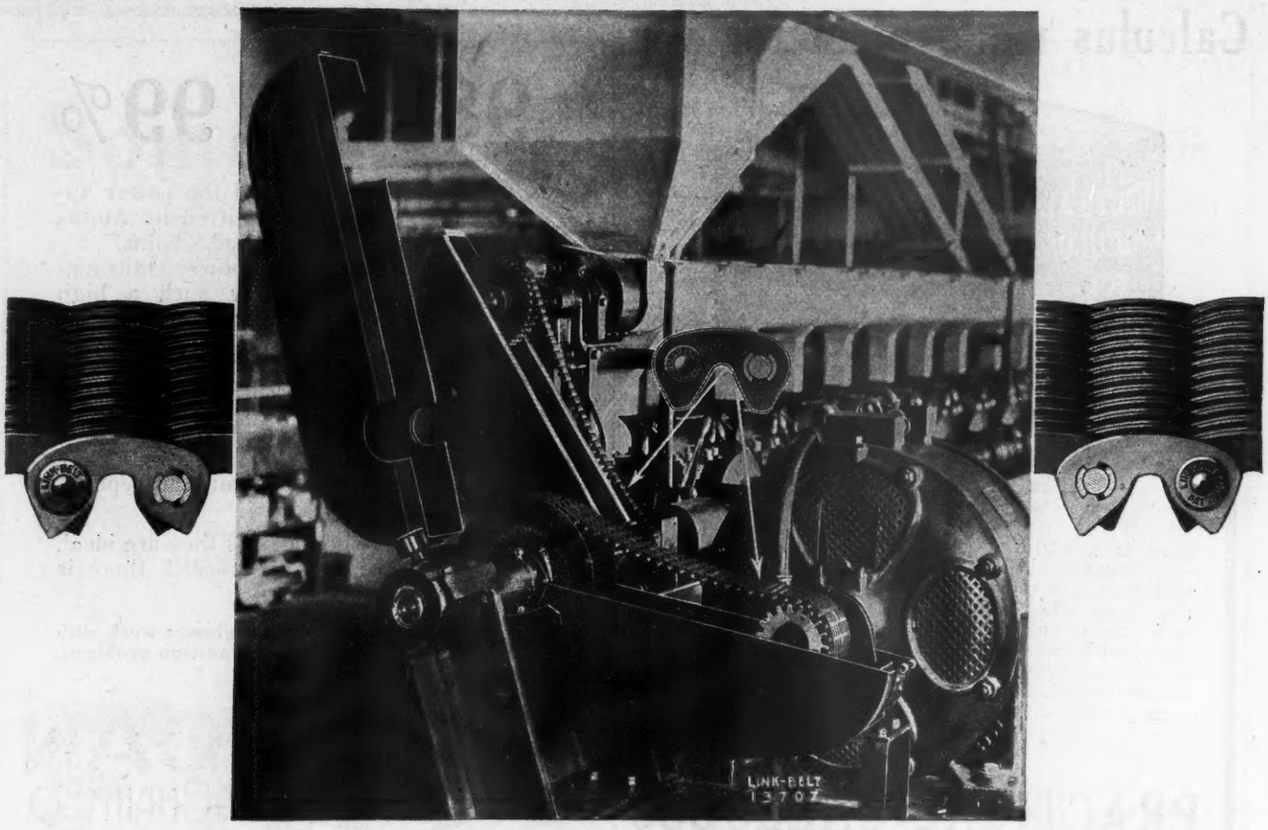
15 LOCK STREET **BUFFALO, N. Y.**

ELWELL-PARKER
6000 POUND
ELECTRIC LIFT TRUCK

Will pick up and deliver more materials day after day at less cost than any similar truck.

Request details as to this new Special, illustrated in Bulletin A535

***The* Elwell-Parker Electric Company**
CLEVELAND



"20 Years of Satisfactory Service"

THAT is a statement by Mr. Frank Meyer, superintendent of the Shredded Wheat Company, about a number of Link-Belt Silent Chain drives which were substituted for belt drives in 1904. He continues:

"From these early installations we learned that Link-Belt Silent Chain saved power, eliminated slippage, reduced journal friction, afforded a positive speed control and reduced operating and maintenance costs. In fact we found it so much more satisfactory than other means of transmitting power that we gradually added more until today we have over 215 Link-Belt Silent Chain drives operating various types of machines. We would consider no other."

Learn what this flexible, positive, efficient power transmission can do in your factory. Price List Data Book No. 125 on request.

1901

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826 Second National Bank Bldg.

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Cleveland - - - - - - 329 Rockefeller Bldg.
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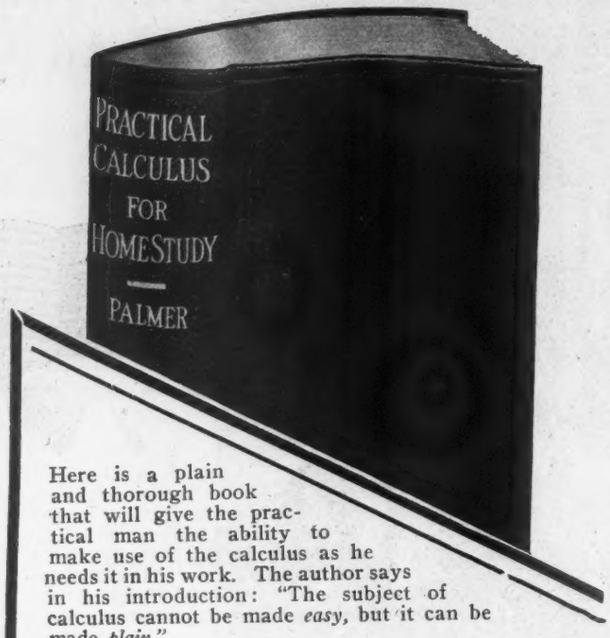
LINK-BELT
SILENT CHAIN DRIVES

Calculus made plain for you



Here is a plain and thorough book that will give the practical man the ability to make use of the calculus as he needs it in his work. The author says in his introduction: "The subject of calculus cannot be made *easy*, but it can be made *plain*."

PALMER'S
PRACTICAL CALCULUS
For Home Study

By C. I. Palmer
Armour Institute of Technology

443 pages, pocket size, flexible, 186 illustrations, $3.00 net, postpaid

This book is for the man with limited mathematical training who has need for a working knowledge of calculus and its practical applications. It shows just what kind of problems can be solved with the aid of calculus and explains thoroughly and clearly how.

You have been waiting for this book

A working knowledge of calculus is of such advantage that hundreds of men have been asking for just such a simple and understandable book as this one. The book avoids involved mathematical terms and phrases. It covers every point plainly. It tells you the many practical uses to which calculus can be put—how you can use it daily—how it can help in your work.

Examine a copy *Free* for 10 days

Examine this book FREE for 10 days. See it for yourself—see how plain the book makes calculus. Just send the coupon today. You are under no obligation to purchase the book unless the 10-day trial period convinces you it is worth twice its small cost.

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FREE EXAMINATION COUPON

McGraw-Hill Book Co., Inc., 370 Seventh Avenue, New York.
You may send me on 10 days' approval Palmer's Practical Calculus for home study, $3.00 net, postpaid. I agree to remit for the book or to return it postpaid within 10 days of receipt.

Signed .....

Address .....

Official Position .....

Name of Company .....

(Books sent on approval to retail purchasers in U. S. and Canada only.) I.E. 12-1-24

98% to 99%

98% to 99% of the power applied is transmitted by American High Speed Chains. No other form of power transmission can show such a high percentage of efficiency.

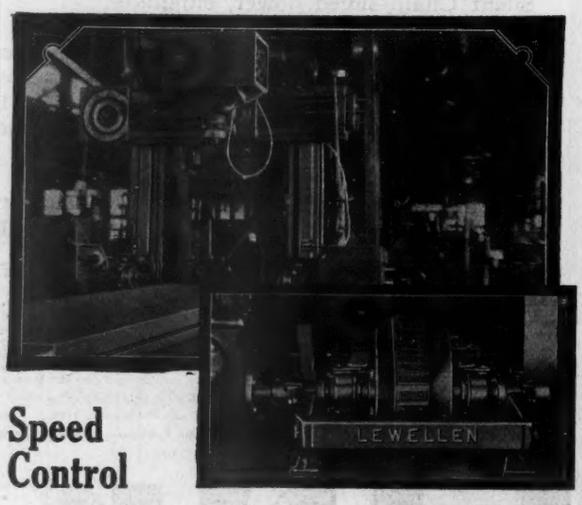
Yet this is only one of the outstanding features of American High Speed Chains. They run without initial tension and practically no friction. They are smooth, silent, and dependable.

For short drives they are ideal. No idlers are needed, there is no slippage.

Let one of our engineers work with you on your transmission problems. No obligation.

AMERICAN HIGH SPEED CHAIN CO.
INDIANAPOLIS, U. S. A.

LEWELLEN
Variable Speed
TRANSMISSION



Speed Control

Here is an application of the Lewellen Variable Speed Transmission to a milling machine in the plant of Thomas L. Green & Company, Indianapolis. Although the Lewellen costs less than 2% of the price of the miller, it controls the entire output, improves the work and renders the machine many times more valuable.

LEWELLEN MFG. CO., Columbus, Ind.

Somewhere in Your Plant—

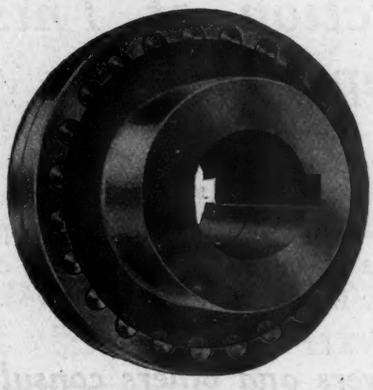
Somewhere in your plant there is a coupling which is not giving all the power it should, which is wearing prematurely or which is constantly breaking. The Falk-Bibby Coupling has shown remarkable efficiency under even the most trying conditions and, because of its perfect lubrication, is practically free from wear.

The greater the shocks, the more irregular the load, the more frequent the vibration, the more this coupling demonstrates its great superiority.

The Falk Corporation, Milwaukee

FALK —BIBBY COUPLINGS

Flexible couplings for every service



5 Types of Francke Flexible Couplings
Pressed Steel Type—for Fractional H. P. Drives.
Heavy Pattern Type—a general purpose coupling.
High Speed Type—for High Speed drives.
Double Type—for heavy duty, continuous drives.
Marine Type—used on small power boats.

FRANCKE FLEXIBLE COUPLINGS

"They make good machines last longer"

In all Francke designs laminated steel springs provide for shaft misalignments in every direction. They cushion load shocks and vibrations. Where needed they also act as a safety device.

Ask for Bulletin No. 37.

SMITH & SERRELL
Coupling Specialists Since 1912 .
26 Washington Place, Newark, N. J.
District Office, Fulton Building, Pittsburgh

Get *ALL* the power you pay for

Most shops are finding that the drive layout delivering the most power at the lowest cost per unit produced per year is the group drive using leather belts.

Leather belts transmit more power with less slippage and less bearing friction than any substitute. They have a longer life and a higher salvage value than substitutes.
From actual shop experience, the group drive with leather belts averages 1/6 as much time lost through breakdowns as the individual drive.

Read this:

Robert W. Drake, electrical engineer of the McCormick International Harvester Plant, has written three articles which have been reprinted in pamphlet form "When to Use Group and Individual Drives." He knows drives and belts—he has used nearly every kind of tool—HIS PAMPHLET IS PRACTICAL.

Use the coupon today;
it has put money in other pockets—get yours.

LEATHER BELTING EXCHANGE
Philadelphia, Pa.

Nothing takes the place of
LEATHER

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ON the other hand, in February this year there will be an exhibit (on paper) of mechanical and electrical equipment especially and entirely adapted to the newer developments in industrial conditions, every item of which will concern you directly or indirectly. An exhibition without frills, without wasted effort, without lost motion or time. The February issue of Industrial Engineer will be, in effect, a convention of operating men from all parts of the country. The stories and articles to appear in this number, have been collected by editors traveling many thousands of miles and attending the largest conventions of the past year.

A national survey of industrial plant changes that tend to improve operating conditions will appear in the February issue of

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Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

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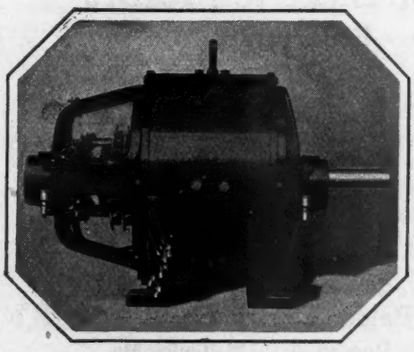

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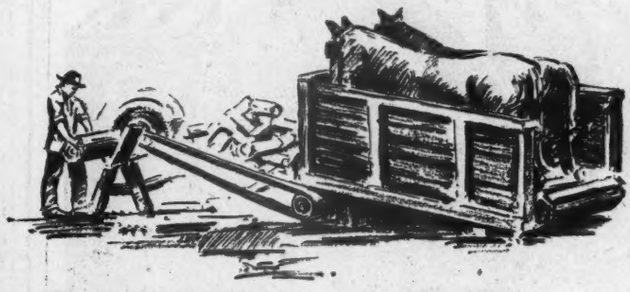

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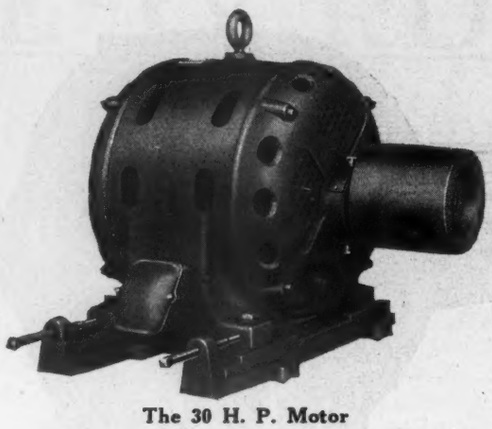

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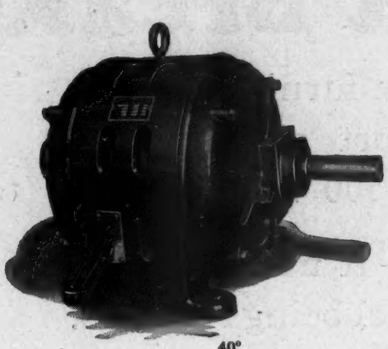

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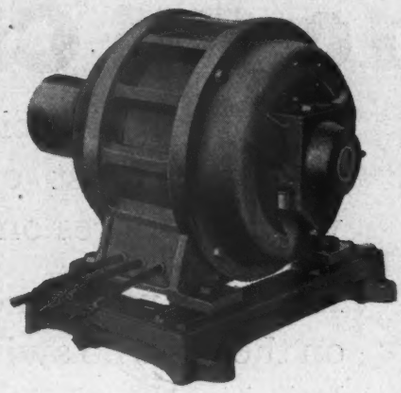

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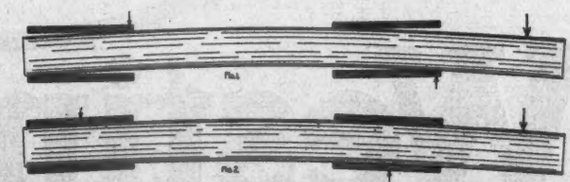
How Hertner bearing design eliminates the chief cause of trouble



The upper diagram shows what happens when the pull comes on the shaft in the ordinary motor. The bearing surface becomes an edge, and the wear concentrates.

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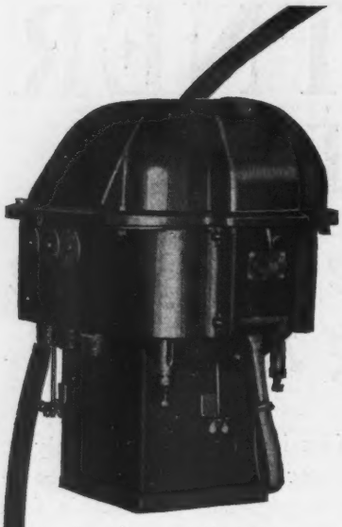

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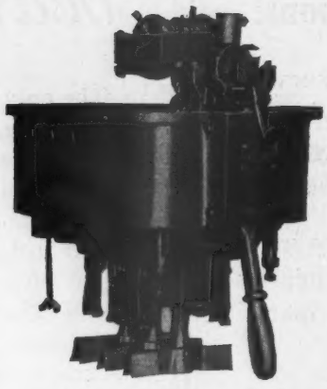

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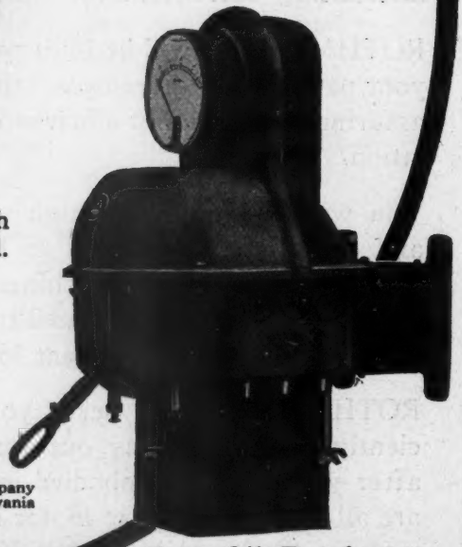
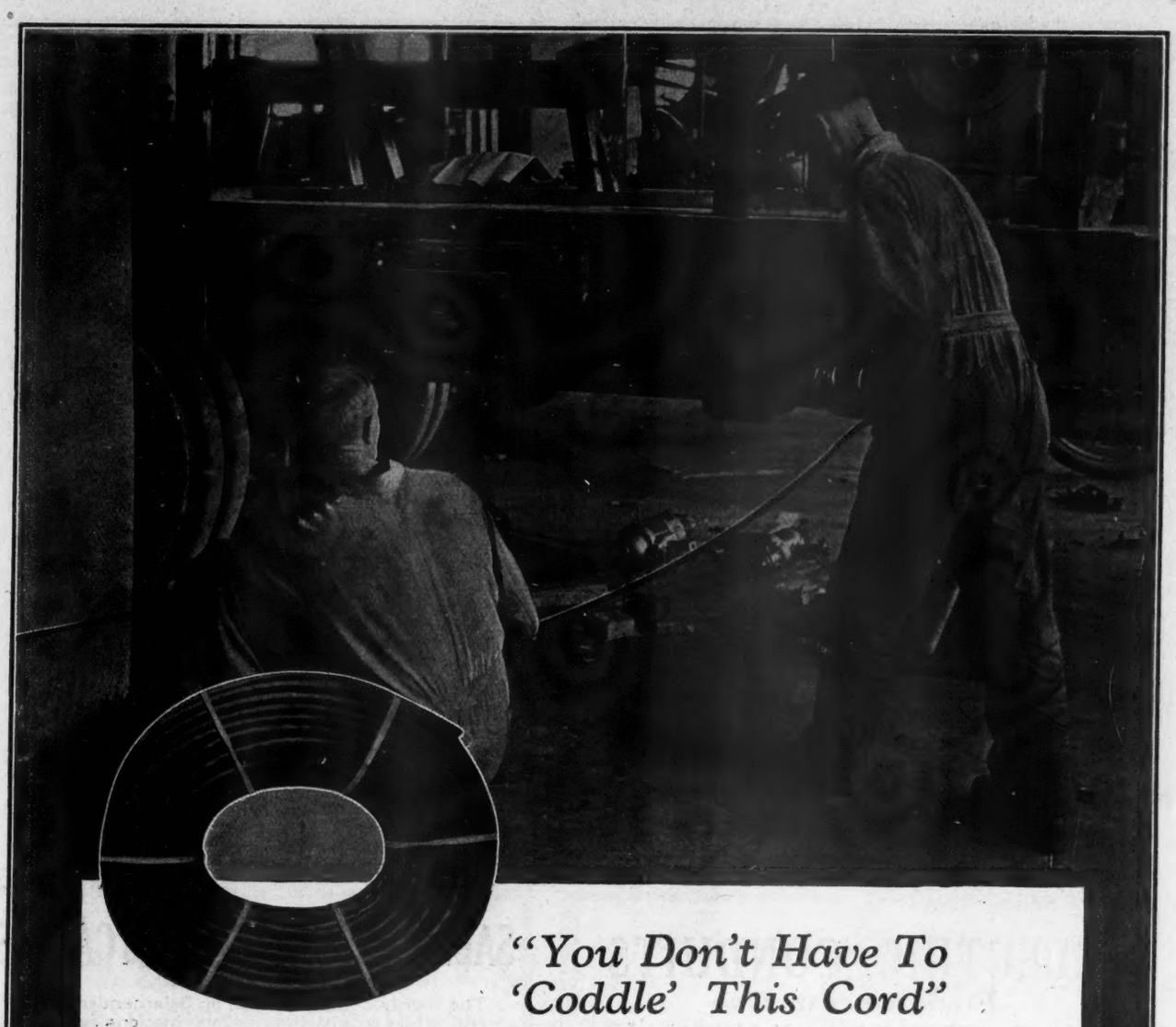


F-10 Oil Breaker, with Ammeter to indicate load conditions.

Westinghouse



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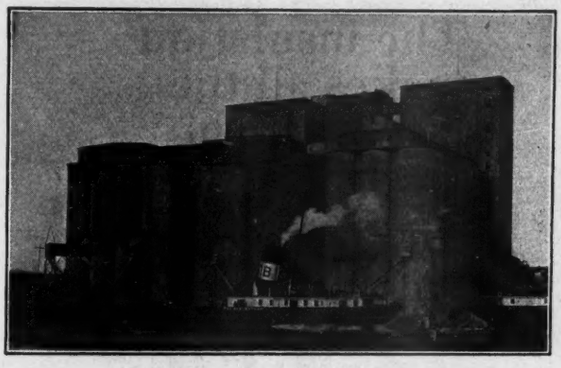

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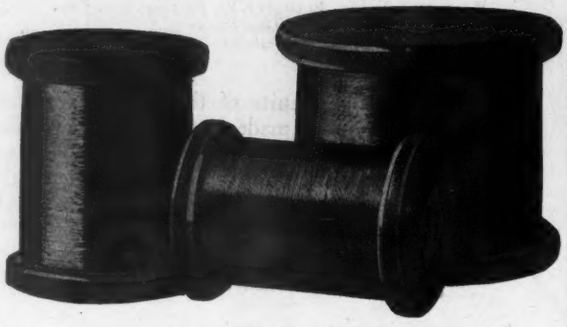

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WARREN, O.
BUILDERS OF TRANSFORMERS SINCE 1890

TRANSFORMERS

That's Us!

LARGE OR SMALL. When you are in the market for transformers, get our quotations. *Any voltage—any capacity.* We are in position to give prompt deliveries on quality built transformers.

Campbell Mfg. Company

19 Stewart Street **Lynn, Mass.**

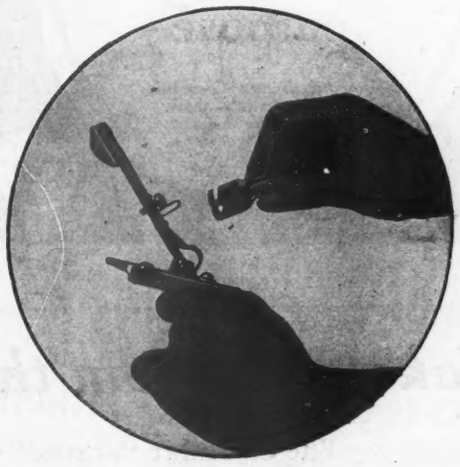
Why **UNION**

DRUM CONTROLLERS

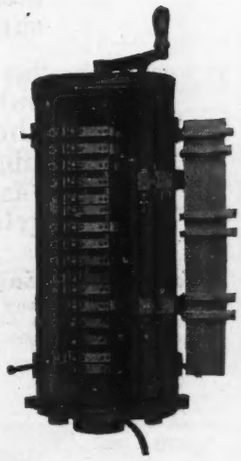
give such continuous trouble-free service

A few of the many features that distinguish Union Drum Controllers and enable them to stand severe service with great success.

"Perfection" non-stubbing fingers which can be detached, dressed or tip renewed, and replaced in less time than it takes to remove an ordinary controller finger.



A screw driver is the only tool required to remove fingers. The finger board is removable without disturbing any other part.

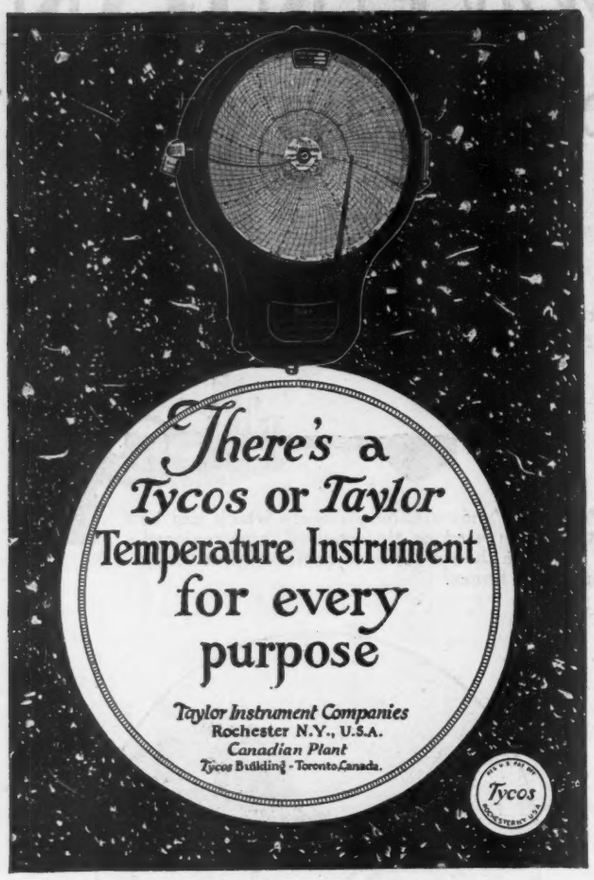


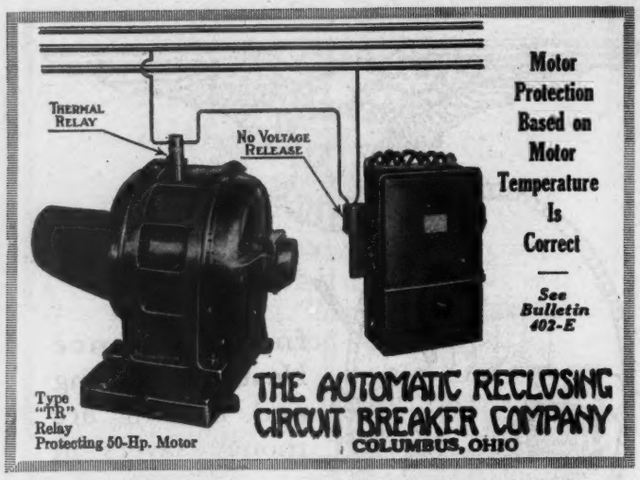
Drum controllers for cranes, hoists, derricks, tractors, trucks, mine locomotives, metal and woodworking machinery, and all general purpose applications for slip ring, squirrel cage, multi-speed and direct current motors.

Send for "Publication 500" giving complete details of drum controllers and accessories

UNION ELECTRIC MANUFACTURING CO.

Milwaukee, Wisconsin




Thermal Relay
No Voltage Release
Motor Protection Based on Motor Temperature Is Correct
See Bulletin 402-E
Type "TR" Relay Protecting 50-Hp. Motor
THE AUTOMATIC RECLOSING CIRCUIT BREAKER COMPANY
COLUMBUS, OHIO

Take a tip from the calendar

The calendar "starts" with the first of the year. Your subscription to Industrial Engineer ought to start at the same time.

So—if you are not numbered among the enthusiastic subscribers to this publication lose no time in filling in the coupon—and then mailing it! Just in time for the big January number which will start (in noteworthy fashion) another year of service for the industrial electrical mechanical man. Take a tip from the calendar!

To Industrial Engineer
1570 Old Colony Bldg., Chicago

Enclosed find $2 for which please enter my subscription to Industrial Engineer. (Note: While the regular subscription price is $2 per year a special offer of 2 years for $3 is now being made.)

Name _____

Address _____

City _____ State _____ Co. _____

Title (or position) _____

Company Associated with _____

Department (construction, installation, repair, etc.) _____

Principal product of company _____

I am most interested in the following subjects: _____

12-24

SEARCHLIGHT SECTION

EMPLOYMENT-BUSINESS OPPORTUNITIES-EQUIPMENT

UNDISPLAYED—RATE PER WORD:

Positions Wanted, 4 cents a word, minimum 75 cents an insertion, payable in advance.

Positions Vacant and all other classifications, 8 cents a word, minimum charge $2.00.

Proposals, 40 cents a line an insertion.

INFORMATION:

Box Numbers in care of any of our offices count 10 words additional in undisplayed ads.

Discount of 10% if one payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

1 to 3 inches.....$5.00 an inch
4 to 7 inches..... 4.80 an inch
8 to 14 inches..... 4.60 an inch

An advertising inch is measured vertically on one column, 3 columns—30 inches—to a page.

I. E.

WANTED—Scrap platinum, old gold and silver, mercury, Cooper Hewitt lamps, old magneto and coil points. We pay highest cash prices.

Contact Metals Company
Dept. D, 221 E. 23rd Street, Chicago, Ill.

PROPERLY rebuilt equipment guaranteed to operate the same as new machines are dependable and save you money. Write for quotations on motors, generators, transformers, etc.

Over 8000 units in stock.

THE FUERST-FRIEDMAN, Cleveland, Ohio

BE A METER ENGINEER

Get in the new profession. We can teach you meter engineering by mail at your own home during spare time. Successful graduates everywhere.

EARN $3,600.00 A YEAR

Central stations must have Electrical Meter Engineers. They pay high salaries. Write today. Just your name and address on a postal and we will send you full particulars free. Ft. Wayne Correspondence School, Dept. 80, Ft. Wayne, Ind.

Distributors **G.E. MOTORS** *and* **CONTROL EQUIPMENT**

Motors of practically every size and description—ready to ship from Toledo stock

Greatly increased stock of **GUARANTEED 'NAGEL REBUILT' MOTORS and GENERATORS** on hand. Large quantities, late types—standard makes at new low prices.

We Exchange, Sell, Buy
Rent and Repair

THE W.G. NAGEL ELECTRIC CO.
28-30-32-34-36 SAINT CLAIR STREET
TOLEDO, OHIO.

POSITIONS WANTED

APPRAISAL ENGINEER C. E.—Seven years experience in public utility and industrial valuation, desires position. Address PW-165, Industrial Engineer, 10th Ave. at 36th St., New York City.

A GOOD LAYER COIL WINDER is looking for a chance of a. c. armature winder. Clean record. Wages easily arranged. Must be steady and a good place. Address PW-166, Industrial Engineer, Old Colony Bldg., Chicago, Ill.

ADVERTISEMENT FOR POSITION—Power house or substation operator wants position. Six years' experience. Age 38. Married, sober and worker. Any location available on ten day notice. Good reference. Write W. L. Parks, Den. Sta., Greensboro, N. C.

BARGAIN — Slow Speed Motors

Two 200 H. P. New 235 R. P. M. Westinghouse Electric Motors at fraction of original cost.

STANDARD ELECTRIC MACHINERY COMPANY
9 East Hill Street, Baltimore, Md.

A Personal Want

can be filled through many channels.

A Business Want

can best be satisfied by others in your industry.

"SEARCHLIGHT" ADS

in this paper reach the latter.

They cost little and invariably produce prompt returns.

For Every Business Want

"Think* SEARCHLIGHT *First"

FOR SALE

7 Reducing Worm Drives

made by the Cleveland Worm & Gear Company; Ratio 60 to 1, Serial No. 100-A, 1200 R.P.M., 1 H.P. Address

The Celluloid Co.
290 Ferry St. Newark, N. J.

Electricity at your finger ends

Know the facts in Electricity. They mean more money and better position for you. Hawkins Guides tell you all you need to know about Electricity.

Every important electrical subject covered so you can understand it. Easy to study and apply. A complete, practical working course, in 10 volumes.

Books are pocket size; flexible covers. Order a set to-day to look over.

HAWKINS GUIDES

3500 PAGES **$1 A VOLUME**
4700 PICTURES **$1 A MONTH**

These books tell you all about—

Magnetism—Induction—Experiments—Dynamos—Electric Machinery—Motors—Armatures—Armature Windings—Installing of Dynamos—Electrical Instrument Testing—Practical Management of Dynamos and Motors—Distribution Systems-Wiring-Wiring Diagrams—Sign Flashers—Storage Batteries—Principles of Alternating Currents and Alternators—Alternating Current Motors—Transformers—Converters—Rectifiers—Alternating Current Systems—Circuit Breakers—Measuring Instruments—Switch Boards—Wiring—Power Stations—Installing—Telephone—Telegraph—Wireless—Bells—Lighting—Railways. Also many Modern Practical Applications of Electricity and Ready Reference Index.

SHIPPED TO YOU FREE

Not a cent to pay until you see the books. No obligation to buy unless you are satisfied. Send Coupon now—today—and get this great help library and see if it is not worth $100 to you—pay $1.00 a month for ten months or return it.

SEND NO MONEY

THEO. AUDEL & CO., 72 Fifth Ave., N. Y.

Please submit for examination **Hawkins Electrical Guides** (Price $1 each). Ship at once, prepaid, the 10 numbers. If satisfactory, I agree to send you $1 within seven days and to further mail you $1 each month until paid.

Signature_____
Occupation_____
Employed by_____
Residence_____
Reference_____

WINDING DATA FOR ALTERNATING CURRENT MOTORS

A printed Manual giving the actual rewinding data for two and three phase motors of the twelve leading manufacturers. This book will be appreciated by any motor repair shop. It will save delays for lack of the necessary rewinding data, give you the actual data necessary to change the speed, phase or horse power.

CONNECTING DIAGRAMS FOR ELECTRICAL DEVICES

This office is able to furnish you with blueprint diagrams, for nearly any kind of an electrical device. Many are made up into sets and manuals. A list of these are as follows: Alternating Current Motors, Transformers, Wave Wound Rotors, Current Regulating Devices, Three Phase Stators and Rotors, Direct Current Generators and Motors, Single Phase Alternators and Motors, Armatures of Automobile Starters, generators and motor-generators.

Circulars and samples sent on request. I do not make "Sight un-Seen" sales, if not satisfied, prints or Manuals can be returned and your money will be refunded.

CHARLES L. CHITTENDEN
Electrical Laboratory
Z3024 Matthews Avenue **Kansas City, Missouri**

ON SALE NOW

Hundreds of GENERAL ELECTRIC KT, 3 PHASE, 60 CYCLE, 220 VOLT MOTORS from the Lincoln Works of the Ford Motor Co., Detroit, sizes ½ HP and upward—all the most desirable sizes and speeds **now available** and in **stock** at our works —at Bargain Prices. You know how Ford **maintains** his equipment—every motor in perfect operative condition. These motors were not taken out of service because obsolete or worn out, but were replaced by 220 volt, direct current motors for **engineering reasons.** Fill in your requirements. Here's your opportunity to get your orders in before they are all sold. We ship on approval. New and used electric generators, motors, meters and transformers. America's largest stock of its kind. We rent, repair and exchange.

GREGORY ELECTRIC CO. CHICAGO, ILLINOIS

16th and Lincoln Sts., Chicago

Repair Service

Here is an organization modernly equipped and thoroughly experienced in producing high grade electrical and mechanical repair work. We handle every job intelligently and promptly.

We rewind motors. All rewinds impregnated and baked. We rebuild or reinsulate commutators. Complete machine shop equipment for bearings or new shafts. All work correctly done and guaranteed.

We are organized and prepared to give real service on jobs sent from any section of the country. For economy and satisfaction

Use our service

Advance Electric Co.
INCORPORATED
611-13 W. Adams St., Chicago, Ill.

EDISON SERVICE

OUR REPAIR SHOPS

are prepared to do High Grade Electrical Repair Work of all kinds at a reasonable price.

Electric Lighting Supplies

Inspect our first class stock. You are assured absolute satisfaction and quality.

Telephone Randolph 1280

Commonwealth Edison Company
72 West Adams Street Chicago

MILLER-SELDON ELECTRIC COMPANY
MOTORS SUPPLIES ELECTRICAL CONSTRUCTION

ELECTRICAL SUPPLY JOBBERS AND ELECTRAGISTS
MOTORS SOLD—RENTED—REPAIRED—EXCHANGED

Direct Factory Representatives of

JEANNIN ELECTRIC CO.—SINGLE PHASE MOTORS
TRIUMPH ELECTRIC CO.—POLYPHASE MOTORS

WALNUT 3800 **1930 McGRAW AVE., DETROIT**

Keep your Eye
on the
Searchlight
and your
Advertisements in it

WHAT AND WHERE TO BUY

Equipment, Apparatus and Supplies Advertised in this Issue with Names of Manufacturers and Distributors

Prospective purchasers in the electrical-mechanical market are invited to apprise us of their needs, assuming, of course, that the articles sought are not listed here
INDUSTRIAL ENGINEER, OLD COLONY BLDG., CHICAGO

Arc Welding Sets
Allan Mfg. & Welding Co.

Air Cleaners
Midwest Air Filters, Inc.

Air Compressor Filters
Midwest Air Filters, Inc.

Air Compressors
Allis-Chalmers Mfg. Co.
General Electric Co.

Air Filters
Midwest Air Filters, Inc.

Armature Baking Ovens
Despatch Mfg. Co.

Armature Coil Spreaders
Mutual Foundry & Machine Co.

Armature Coil Winders
Mutual Foundry & Machine Co.

Armature Repair Machinery
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Armature Rewinding
Cleveland Arm. Wks.

Armature Wedges
Crafts Elec. Co., Jas. P.

Balls, Brass, Bronze and Steel
Skayef Ball Bearing Co.

Baking Ovens
Despatch Mfg. Co.

Battery Charging Apparatus
General Electric Co.
Hertner Electric Co.
Westinghouse Elec. & Mfg. Co.

Bearings
Ball
Skayef Ball Bearing Co.
Torrington Co., The
Roller
Bond Co., Chas.
Dodge Mfg. Corp.
Hyatt Roller Bearing Co.

Bearing Metal
General Electric Co.
Stewart Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Bells, Electric
Schwarze Electric Co.
Westinghouse Elec. & Mfg. Co.

Belts, Conveyor
Link-Belt Co.
Schieren Co., Chas. A.

Belt Fasteners
Flexible Steel Lacing Co.

Belt Drives
Smidth & Co., F. L.

Belt Lacings, Hinge
Flexible Steel Lacing Co.

Belts, Transmission
Bond Co., Chas.
Chicago Belting Co.
Link-Belt Co.
Schieren Co., Chas. A.

Blow Torches
Allen Co., L. B.
McGill Mfg. Co.

Blowers
Armature
Clements Mfg. Co.
Electric Blower Co.
Electric Portable
Clements Mfg. Co.
Electric Blower Co.
Green Equipment Corp.
Martindale Electric Co.

Bolts, Nuts and Screws
Sturtevant Co., B. F.

Books, Technical
Audel & Co., Theo.
McGraw-Hill Book Co., Inc.
Sweets's Catalog

Boosters
Allis-Chalmers Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Boxes
Conduit
Appleton Electric Co.
Hubbell, Inc., Harvey
McGill Mfg. Co.
Fuse
General Electric Co.
Junction and Outlet
Appleton Electric Co.
Chicago Fuse Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 82.

General Electric Co.
Hubbell, Inc., Harvey
National Metal Molding Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Meter and Service
General Electric Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Sectional, Switch & Outlet
Appleton Electric Co.
Chicago Fuse Mfg. Co.

Brackets, Instrument
Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.

Brakes
Crane
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Disc
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Electric
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Brushes
Commutator
Calebaugh Self Lubricating Carbon Co.
Corliss Carbon Co.
General Electric Co.
Jeandron, W. J.
Morganite Brush Co., Inc.
Snarr & Co., Geo. W.
Westinghouse Elec. & Mfg Co.
Dynamic and Carbon
Corliss Carbon Co.
Jeandron, W. J.
Morganite Brush Co., Inc
Westinghouse Elec. & Mfg. Co.
Controller
Corliss Carbon Co.

Brush Holders
Baylis Company
Flower, D. B.
Westinghouse Elec. & Mfg Co.

Bus Bar Supports
General Electric Co.
Trumbull Electric Mfg. Co
Westinghouse Elec. & Mfg. Co.

Bushings
Appleton Electric Co.
National Metal Molding Co.

Cable Clamps
Electric Service Supplies Co.

Cable Hangers
Electric Service Supplies Co.

Cable Racks, End Bells and Accessories
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cable Terminal Lugs.
Mutual Elec & Mach. Co.

Casting, Steel
Falk Corp., The

(Continued on page 78)

Surety Motors

Performance Guarantee Backed by Surety Bond

BONDED

What Shape Is It In Now ?

True Stories:

One of our Licensees recently purchased from a customer a 100-H.P., 450 R.P.M. motor. This motor came into the plant with a heavy steel gear on. To all outward appearances the motor was in perfect condition and would make an excellent buy for the purchaser. After removing the gear, which, by the way, took the time of three men two days, owing to the fact that the gear had been put on by hydraulic pressure and the key pounded in with a sledge hammer and had expanded, it was found that the shaft of the motor was sprung, which necessitated putting in a new shaft before the motor could be sold under the specifications of the Surety Motor Bonding Company.

There are cases where second hand dealers sell motors with the shafts sprung. The purchaser probably pays 25% cash with order and the balance sight draft against Bill of Lading, and then he has a machine that he has to add a lot of expense to to put it in operative condition or it is valueless to him.

This hazard is eliminated in buying a S.M.B. motor. If, by accident, some fault does get by, it will be remedied by the selling licensee. The Surety Bond guarantees that.

Ask the Licensees Named Below for Lists of and Full Information on Surety Bonded Renewed Motors:

Duquesne Electric & Mfg. Co.,
Duquesne Corner, Broad St. and Hamilton Ave., Pittsburgh, Pa.
Elliott Electric Co. . . . . 813 Superior Ave., W., Cleveland, Ohio
Miller-Seldon Electric Co. . . . . 1930 McGraw Ave., Detroit, Mich.
Willey-Wray Electric Co. . . . 1523-25-27 Central Parkway, Cincinnati, Ohio

Surety Motor Bonding Company

SURETY RENEWED MOTORS BONDED

SURETY MOTORS (BONDED)

133 W. Washington St., Chicago, Ill.

"What & Where to Buy"

(Continued from page 76)

Cement
Commutator
Martindale Electric Co.
Leather Belt
Chicago Belting Co.

Chains
American High Speed Chain Co.
Link-Belt Co.
Ramsey Chain Co., Inc.

Chucks, Drill & Tap
Skayef Ball Bearing Co.

Circuit Breakers
Automatic Reclosing Circuit Breaker Co.
Condit Electrical Mfg. Co.
Cutler-Hammer Mfg. Co.
Cutter Co.
General Electric Co.
Roller-Smith Co.
Westinghouse Elec. & Mfg. Co.

Clamps
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Clean Air Equipment
Milwest Air Filters, Inc.

Cleats
National Metal Molding Co.
Square D Co.
Trumbull Elec. Mfg. Co.
Thomas & Sons Co., R.

Clutches
Friction
Allis-Chalmers Mfg. Co.
Dodge Mfg. Corp.
Link-Belt Co.
Magnetic
Cutler-Hammer Mfg. Co.

Coal and Ash Handling Equipment
Link-Belt Co.

Coatings, Preservative
Sterling Varnish Co.

Coil Winding Machines
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coil Winding Tools
Armature Coil Equipment Co.
Electric Service Supplies Co.
Mutual Foundry & Machine Co.

Coils, Choke
American Transformer Co.
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Coils, Induction
American Transformer Co.

Commutators
Cleveland Armature Wks.

Compensators
Automatic
Cutler-Hammer Mfg. Co
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.
Manual
Allis-Chalmers Mfg. Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Industrial Controller Co.
Westinghouse Elec. & Mfg. Co.

Conductors, Armored
Tubular Woven Fabric Co.

Conduit Benders
American Pipe Bending Mach. Co.

Conduits
American Circular Loom Co.
National Metal Molding Co.
Tubular Woven Fabric Co.

Connectors & Terminals
General Electric Co.
Mutual Electric & Machine Co.
Trumbull Electric Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Contacts, Carbon and Metal Graphite
Corliss Carbon Co.

Contact Rail Material
Electric Service Supplies Co.

Controller Fingers
Russell Mfg. Co.

Controllers
Automatic
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Coal and Ore Bridges
Electric Controller & Mfg. Co.
Crane
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Drum Type
General Electric Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Machine Tool
Electric Controller & Mfg. Co.
Monitor Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Manual
Allen-Bradley Co.
Electric Controller & Mfg. Co.
Industrial Controller Co.
Union Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Motor
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Electric Controller & Mfg. Co.
General Electric Co.
Industrial Controller Co.
Lewellen Mfg. Co.
Monitor Controller Co.
Union Elec Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Conveyors
Link-Belt Co.
Weller Mfg. Co.

Cooling Air Filters
Midwest Air Filters, Inc.

Cord, Flexible
Hubbell, Inc., Harvey
Rome Wire Co.
Tubular Woven Fabric Co.
U. S. Rubber Co.

Couplings, Flexible
Allis-Chalmers Mfg. Co.
Bartlett Hayward Co.
Bond Co., Chas.
Dodge Mfg. Corp.
Electric Controller & Mfg.
Falk Corp., The
Foote Bros., Gear and Machine Co.
Smith & Serrell

Crane Controllers
Drum Type
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Magnetic
Allen-Bradley Co.
Cutler-Hammer Mfg. Co.
Westinghouse Elec. & Mfg. Co.
Graphite Compression
Allen-Bradley Co.

Crane Motors
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Cranes, Portable
Canton Foundry & Mach. Co.

Cross Arms
Electric Service Supplies Co.

Cutouts
Chicago Fuse Co.
General Electric Co.
Hubbell, Inc., Harvey
Mutual Electric & Machine Co.
Square D Co.
Thomas & Sons Co., R.
Trumbull Elec. & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Cutters
Hole
Koch & Co., Paul W.

Cutters, Slotting
Commutator
Hullhorst Micro Tool Co.
Copper
Hullhorst Micro Tool Co.

Diagrams
Chittenden, Charles L.
McGraw-Hill Book Co., Inc.

Disc Brakes
Electric Controller & Mfg. Co.

Dressing, Belt & Rope
Chicago Belting Co.

Drives
Smidth & Co., F. L.

Drives, Silent Chain
American High Speed Chain Co.
Link-Belt Co.
Ramsey Chain Co., Inc.

Dust Filters
Midwest Air Filters, Inc.

Dynamos
Allis-Chalmers Mfg. Co.
Marble-Card Elec. Co.
Westinghouse Elec. & Mfg. Co.

Electric Lighting
Westinghouse Elec. & Mfg. Co.

Elevators & Conveyors
Link-Belt Co.
Weller Mfg. Co.

Enamels, Wire, Wood and Steel
Sterling Varnish Co.

Engineers, Illuminating
Westinghouse Elec. & Mfg. Co.

Engines Oil
Allis-Chalmers Mfg. Co.
Falk Corp., The.

Factory Furniture
Westinghouse Elec. & Mfg. Co.

Factory and Mill Lighting
Westinghouse Elec. & Mfg. Co.

Fan Belts, Leather
Chicago Belting Co.

Fan Motors
Century Electric Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Fans
Exhaust and Ventilating
Century Electric Co.
Diehl Mfg. Co.
General Electric Co.
National Screw & Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Files, Commutator Slotting
Martindale Electric Co.

Filters, Air
Midwest Air Filters, Inc.

Fittings
Conduit
Appleton Electric Co.
Chicago Fuse Mfg. Co.
National Metal Molding Co.
Pipe
Westinghouse Elec. & Mfg. Co.

Fixtures, Lighting
American Fixture Co.
McGill Mfg. Co.
Sampson Axcess System, Inc.
Westinghouse Elec. & Mfg. Co.

For the addresses of the manufacturers listed here, please refer to their advertisements in this issue. The index to advertisers may be found on page 82.

Furnaces, Electric.
Westinghouse Elec. & Mfg. Co.

Fuse Clips
Trumbull Electric Mfg. Co.

Fuse Plugs
Hubbell, Inc., Harvey
Westinghouse Elec. & Mfg. Co.

Fuses
Chicago Fuse Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Renewable
Bussman Mfg. Co.
Chicago Fuse Mfg. Co.
Westinghouse Elec. & Mfg. Co.

Gears
Chicago Rawhide Mfg. Co.
Diamond State Fibre Co.
Dodge Mfg. Corp.
Falk Corp., The
Foote Bros. Gear and Machine Co.
General Electric Co.
Link-Belt Co.
Smith, Winfield H.
Westinghouse Elec. & Mfg. Co.

Generating Sets
Allis-Chalmers Mfg. Co.
General Electric Co.
Marble-Card Electric Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Generators
Allis Co., The Louis
Allis-Chalmers Mfg. Co.
Burke Electric Co.
Electro Dynamic Co.
General Electric Co.
Hertner Electric Co.
Marble-Card Electric Co.
Reliance Elec. & Eng. Co.
Triumph Electric Co.
Westinghouse Elec. & Mfg. Co.

Glue Pots
Westinghouse Elec. & Mfg. Co.

Grinders
Martindale Electric Co.

Grinding Machinery
Smidth & Co., F. L.

Hammers, Rawhide
Chicago Rawhide Mfg. Co.

Hangers, Line Shaft
Dodge Mfg. Corp.
Link-Belt Co.

Hangers, Safety Disconnecting
Cincinnati Specialty Co.
Thompson Electric Co.

Heating & Ventilating Equipment
Midwest Air Filters, Inc.

Heating Devices, Industrial
Campbell Mfg. Co.
Despatch Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

Hoists
General Electric Co.
Link-Belt Co.

Instrument Transformers
American Transformer Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

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Graphic
General Electric Co.
Westinghouse Elec. & Mfg. Co.
Indicating
Biddle, James G.
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Taylor Instrument Co.
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Weston Electrical Ins't Co.
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General Electric Co.
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Biddle, James G.
Cory & Son, Inc., Chas.
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Sterling Varnish Co.
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Cutler-Hammer Mfg. Co.
Mitchell-Rand Mfg. Co.
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Carlson-Dunn Co.
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Okonite Co., The
U. S. Rubber Co.
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Dunn, J. Struthers.

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Trouble
McGill Mfg. Co.

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General Electric Co.
National Screw & Mfg. Co.
Sampson Axcess System, Inc.
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Roller-Smith Co.
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General Electric Co.
Westinghouse Elec. & Mfg. Co.

(Continued on page 80)

FUME-PROOF

This EC&M Automatic Compensator is still working after four years with no trouble of any kind.

Think of what it has been through. It operates a motor driving a gas producer and gases are in the air all the time.

It is located outdoors and gets 100° weather in the summer and zero weather in the winter.

It has been rained on and it has been snowed on.

Yet it is still working after four years without a failure.

EC&M Automatic Compensators can be supplied for any voltage up to 2300 Volts.

Write for Bulletin 1042-D

E&M

THE ELECTRIC CONTROLLER & MFG. CO.

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BIRMINGHAM-BROWN-MARX BLDG.
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TORONTO-TRADERS BANK BLDG.

E&M

"What & Where to Buy"

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Mica, Undercutting Machines
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National Metal Molding Co.

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Slotters, Commutator
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Wiegand, Edwin L.

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Nagel Elec. Co., W. G.
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Westinghouse Elec. & Mfg. Co.

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Westinghouse Elec. & Mfg. Co.

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Cutter Co.
General Electric Co.
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Industrial Controller Co.
Monitor Controller Co.
Westinghouse Elec. & Mfg. Co.
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Westinghouse Elec. & Mfg. Co.
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Hart Mfg. Co.
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McGill Mfg. Co.
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Roller-Smith Co.
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Weston Electrical Ins't Co.

Thermal Relays
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Thermometers, Indicating & Recording
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Varnished Cambric
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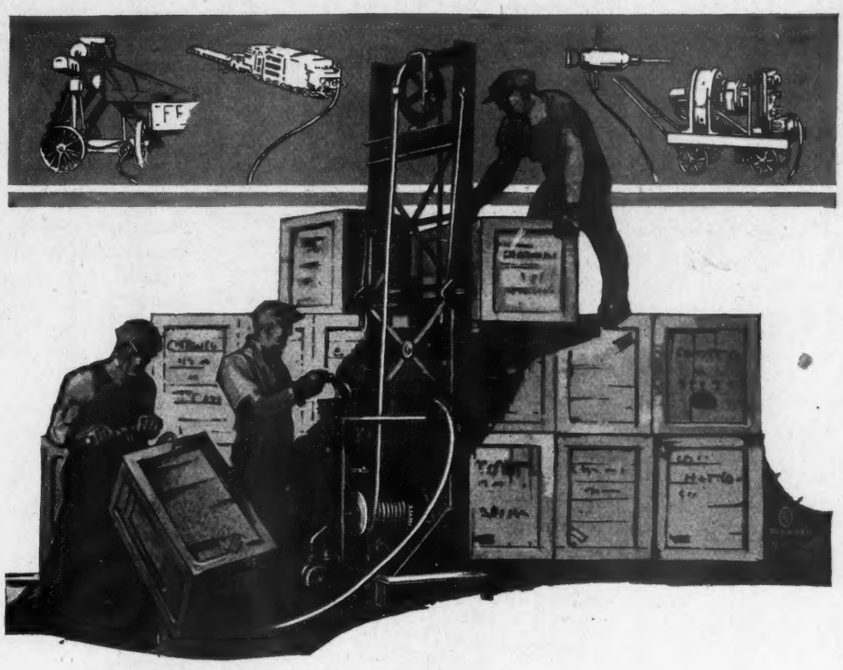
Pittsburgh Mall. Iron Co.



A PORTABLE CORD

for

All Kinds of Hard Service

Wherever portable cord is subjected to hard knocks, abrasion and abuse DURACORD should be used. It is ideal for the Portable Elevator, Coal Loader, Mining Machine, Gathering Locomotive, Portable Motor and Portable Tools of every description.

Its tough woven cover (made like a fire hose) makes it durable, and a positive economy to use it. Many industrial concerns have used DURACORD in quantity and re-ordered again and again.

Ask your Electrical Supply Jobber about DURACORD, or let us send you samples.

TUBULAR WOVEN FABRIC CO.

PAWTUCKET, R. I.

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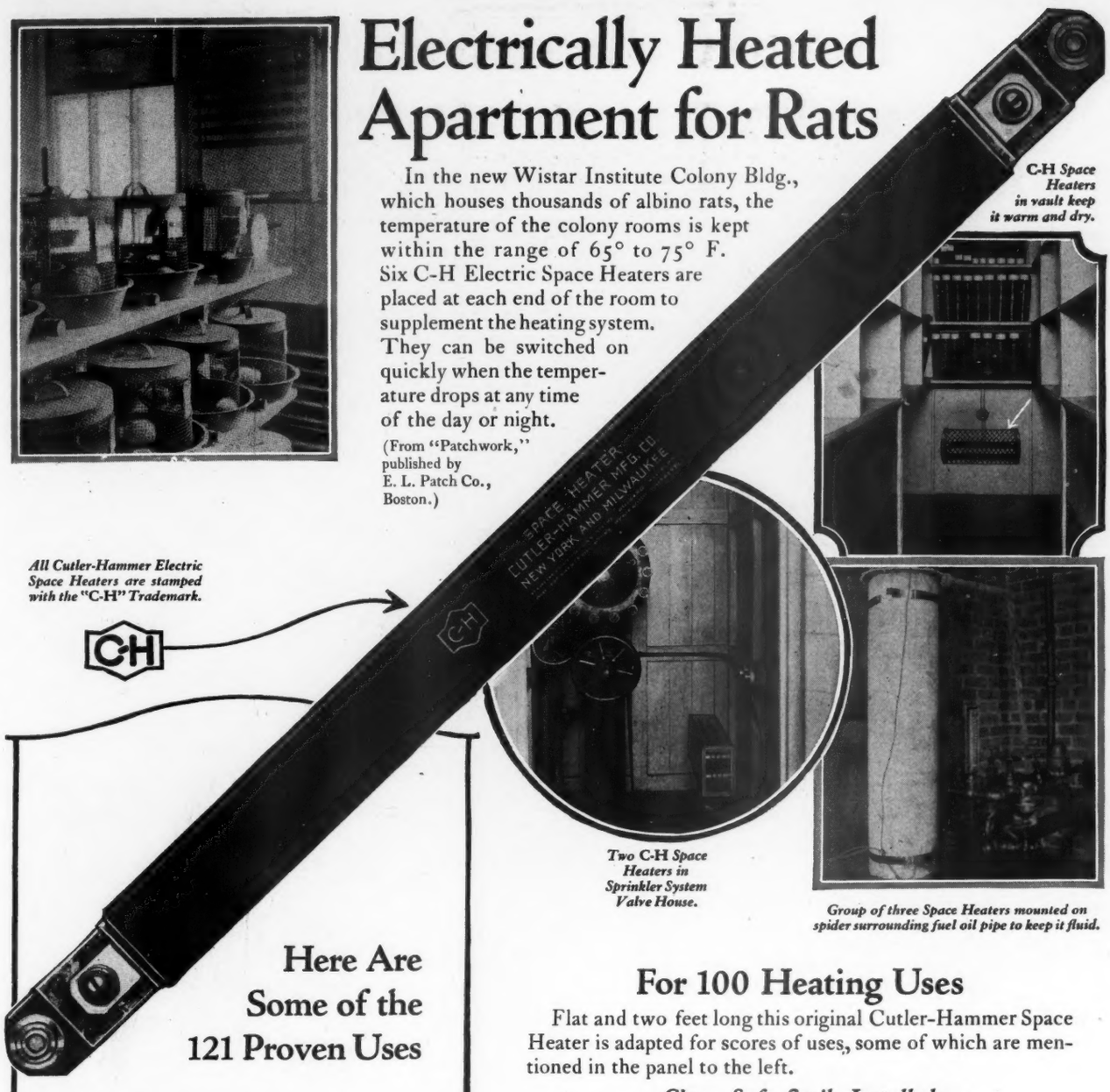
Say you saw it in Industrial Engineer

Electrically Heated Apartment for Rats

In the new Wistar Institute Colony Bldg., which houses thousands of albino rats, the temperature of the colony rooms is kept within the range of 65° to 75° F. Six C-H Electric Space Heaters are placed at each end of the room to supplement the heating system. They can be switched on quickly when the temperature drops at any time of the day or night.

(From "Patchwork," published by E. L. Patch Co., Boston.)



All Cutler-Hammer Electric Space Heaters are stamped with the "C-H" Trademark.

C-H

C-H Space Heaters in vault keep it warm and dry.

Two C-H Space Heaters in Sprinkler System Valve House.

Group of three Space Heaters mounted on spider surrounding fuel oil pipe to keep it fluid.

Here Are Some of the 121 Proven Uses

Sprinkler Systems	Incubators
Valve Houses	Brooders
Gum Drying Ovens	Around Fuel Oil Pipes
Negative Drying Cabinets	In Watchman Towers
Room Heating	Cafeteria Serving Tables
Mine First Aid Stations	Vaults
Theatre Ticket Booths	Garages
In connection with Ventilating Systems	Warming Ovens
Crane Cabs	Foot Warmers
Coal Tipples	Substations
	Pits
	Manholes

For 100 Heating Uses

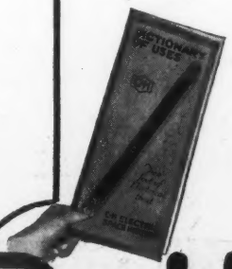
Flat and two feet long this original Cutler-Hammer Space Heater is adapted for scores of uses, some of which are mentioned in the panel to the left.

Clean, Safe, Easily Installed
500 *Watts (like an Electric Iron)*

The insulated mounting eyelets make installation easy. Connection may be made to either direct or alternating current light or power circuits.

If your electric supply jobber cannot supply you promptly, get in touch with the Cutler-Hammer branch office nearest you.

Send for this booklet



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Detroit: 506 Hofman Bldg.
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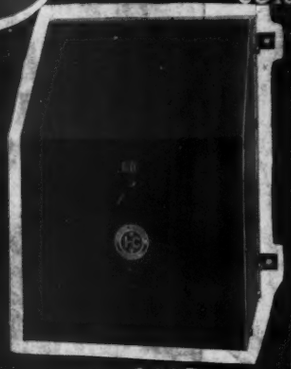

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